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*Example of systematic hierarchy and synonymy:*  
Family Cardiidae Lamarck, 1809  
Subfamily Cardiinae Lamarck, 1809  
Genus *Acanthocardia* Gray, 1853  
(type species *Cardium aculeatum* Linné, 1758)

*Cardium indicum* Lamarck, 1819  
(Fig. 1A–D, Fig. 2C)  
  
*Cardium hians* Brocchi, 1814: p. 508, pl. 13, fig. 6 (non Spengler, 1799).  
*Cardium indicum* Lamarck, 1819: p. 4.  
*Cardium (Cardium) indicum* Lamarck – Fischer-Piette, 1977: p. 112, pl. 10, fig. 4 (type).

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SALAS C., 1996. Marine Bivalves from off the Southern Iberian Peninsula collected by the Balgim and Fauna 1 expeditions. *Haliotis*, **25**: 33-100.  
GRILL B. & ZUSCHIN M., 2001. Modern shallow- to deep-water bivalve death assemblages in the Red Sea - ecology and biogeography. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **168**: 75-96.  
BOSS K.J., 1982. Mollusca, in Parker S.P. (ed.), *Synopsis and Classification of Living Organisms*. Vol. 1. McGraw-Hill, New York: 945-1166.  
CARTER J.G., CAMPBELL D.C. & CAMPBELL M.R. 2000. Cladistic perspectives on early bivalve evolution, in Harper E.M., Taylor J.D. & Crame J.A. (eds), *The Evolutionary Biology of the Bivalvia*. *Geological Society, London, Special Publications*, **177**: 47-95.  
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# The Oligocene to Miocene chitons (Mollusca: Polyplacophora) of the Aquitaine Basin, southwestern France, and Ligerian Basin, western France. Part 1: Leptochitonidae, Hanleyidae, Ischnochitonidae, Chitonidae, Spinochitonidae fam. nov. and Schizochitonidae

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## Abstract

This study describes the chiton fauna (Mollusca, Polyplacophora) from deposits of the Oligocene to Miocene marine sequence of Aquitaine Basin (southwestern France) and of late Miocene of Ligerian Basin (western France). This first part of the work describes the chitons belonging to six families: Leptochitonidae, Hanleyidae, Ischnochitonidae, Chitonidae, Schizochitonidae and establishes the new family Spinochitonidae. The studied fossils consist of 367 disarticulated valves from many sites in the Aquitanian Basin and one (Moulin Pochas) in the Ligerian Basin. We identified 19 species, 13 of which were already known, and six are described as new: *Leptochiton aturriensis* n. sp., *Parachiton palmorum* n. sp., *Ischnochiton renardi* n. sp., *Connexochiton vivesi* n. sp., *Lucilina saubadeae* n. sp., and *Schizochiton tasteti* n. sp. Spinochitonidae new fam. and *Spinochiton* new gen. are described. *Ischnochiton abbessi* n. comb. and *Spinochiton gaasi* n. comb. were transferred from the original genus *Chaetopleura* based on the new material studied. Some records of previously described species are particularly noteworthy: *Hanleya glimmerodensis*, previously known from the late Oligocene of Germany, is reported for the first time for the middle Oligocene of the Aquitaine Basin; the stratigraphic distribution of *Lepidopleurus benoisti*, *Leptochiton josei*, *Ischnochiton rissoi*, *I. korytnicensis*, *Ischnochiton abbessi*, *Chiton corallinus* and *C. assurrectum* is extended. A complete discussion on the chiton fauna from the Aquitaine and Ligerian Basins, consisting of all the species, in the six families from the present study and additional material, will be given in the second part of this work.

## Key words

Mollusca, Polyplacophora, Systematics, Oligocene, Miocene, France, Aquitaine Basin, Ligerian Basin.

## Riassunto

Viene descritta la fauna a chitoni (Mollusca, Polyplacophora) dai depositi della sequenza marina dall'Oligocene al Miocene del bacino Aquitaniano Francia sudoccidentale) e dal Miocene superiore del bacino Ligeriano (Francia occidentale). Questa prima parte del lavoro descrive i chitoni appartenenti a 6 famiglie: Leptochitonidae, Hanleyidae, Ischnochitonidae, Chitonidae, Schizochitonidae e istituisce la nuova famiglia Spinochitonidae ed il nuovo genere *Spinochiton*. Il materiale studiato consiste di 367 piastre disarticolate da diversi siti nel bacino Aquitaniano e da uno (Moulin Pochas) nel bacino Ligeriano. Sono state identificate 19 specie, di cui 13 già conosciute e 6 descritte come nuove: *Leptochiton aturriensis* n. sp., *Parachiton palmorum* n. sp., *Ischnochiton renardi* n. sp., *Connexochiton vivesi* n. sp., *Lucilina saubadeae* n. sp. e *Schizochiton tasteti* n. sp. Inoltre sono descritti la nuova fam. Spinochitonidae e il nuovo gen. *Spinochiton*. *Ischnochiton abbessi* n. comb. e *Spinochiton gaasi* n. comb. sono trasferiti dal genere *Chaetopleura* sulla base del nuovo materiale studiato. Particolarmente interessante, tra le specie reperite, la presenza di *Hanleya glimmerodensis* nell'Oligocene medio del bacino Aquitaniano, che estende la distribuzione geografica di questa specie, nota in precedenza solo dall'Oligocene superiore della Germania. Viene anche estesa la distribuzione stratigrafica di *Lepidopleurus benoisti*, *Leptochiton josei*, *Ischnochiton rissoi*, *I. korytnicensis*, *Ischnochiton abbessi*, *Chiton corallinus* e *C. assurrectum*. Una discussione completa sulla fauna a chitoni dei bacini Aquitaniano e Ligeriano, comprendente tutte le specie qui descritte e quelle a fronte del materiale ancora in fase di studio, verrà fornita nella seconda parte di questo lavoro.

## Parole chiave

Mollusca, Polyplacophora, Sistematica, Oligocene, Miocene, Francia, bacino Aquitaniano, bacino Ligeriano.

## Introduction

The Oligocene to Miocene marine sequence of the Aquitaine Basin (Fig. 1A) has been well known since the 19th century, and several authors have contributed to the knowledge of the rich and world-famous mollusc faunas (de Basterot, 1825; Grateloup, 1827 to 1847; d'Orbigny, 1852; Mayer, 1857 to 1903; Tournouër, 1861 to

1882; Benoist, 1871 to 1892; Degrange-Touzin, 1880 to 1912), particularly the most famous publication series from this realm, the "Conchologie néogénique de l'Aquitaine", started in 1909, by M. Cossmann and A. Peyrot and, after Cossmann's death in 1924, continued by Peyrot until 1935. Between 1934 and 1975, A. Magne and A.-M. Vergneau-Saubade continued the study of molluscs and more recently, P. Lozouet, A. Cluzaud,





J.-F. Lesport, J.-M. Pacaud, B. Cahuzac, and A. Janssen contributed to the revision of the tertiary molluscs of Aquitaine.

The Miocene marine sequence of the Ligerian Basin (Fig. 1B) was studied since the 19th century and the malacofauna was the object of a monograph from 1837 by Dujardin. Then P.-A. Millet de la Turtaudière, R. Tournouër, C. Mayer, J. de Morgan, G. Dolfuss, P. Dautzenberg, O. Couffon, P. Lecointre, A. Peyrot, M. Glibert, P. Brebion, and A. Lauriat-Rage contributed to the knowledge of mollusks during the last two centuries. More recently L. Ceulemans, F. Van Dingenen and B. Landau began the revision of the mollusks of "Redonian" period.

However Polyplacophora (chitons) have received limited attention (Rolle, 1862; Benoist, 1881; de Rochebrune, 1882), and even Cossman & Peyrot (1917) listed only four species from a few localities of the Aquitaine Basin. No information has been published, to our knowledge, regarding the chiton fauna of the Ligerian Basin.

The present study is based on a large number of chiton valves from many localities of Oligocene (Rupelian) to Miocene (Serravallian) age in the Aquitaine Basin, and from a single site of late Miocene age in the Ligerian Basin. In this first part, the species within the families Leptochitonidae, Hanleyidae, Ischnochitonidae, Chitonidae, Schizochitonidae and the new family Spinochitonidae are considered, while the remaining species will be treated in a second, forthcoming part.

## Material and Methods

The material was collected mainly by two of the authors (J.-F. Lesport and A. Cluzaud) from the 1980s to today, by means of field sampling with the collection of fresh material and large amounts of bulk sediment, including material from outcrops that are no longer accessible. Additional specimens were provided by other collectors (Didier Aucoin, France; Birgitte and Eivind Palm, Denmark; Philippe Renard, France; Jacques van Cuyck, France). Additional material housed at the Muséum d'Histoire naturelle de Bordeaux (France) and at the Natural History Museum Wien (Austria) was examined. The bulk samples were washed in sieves (diameter 0.5, 1.0, 2.0 mm), and the material retained in the 1.0 mm and 2.0 mm fractions were then examined for chiton valves using a stereomicroscope. The digital images were obtained using a Motic SMZ-140 Microscope with the software Motic Images Plus.

Type material of new species is deposited in public institutions, the remaining material is housed in private collections, some of which will later be deposited in public institutions.

The maximum width of the valves (head, intermediate, and tail) of each species is given, with notes also if the valves are incomplete, or are only small fragments. Where the number of the valves for a species is small (< 10), we give the maximum width of the valves for each locality.

The following abbreviations are used:

- C.N.A. Conchologie néogénique de l'Aquitaine (Cossman & Peyrot, 1909 - 1935).
- D.L. French legal deposit.
- IRSN Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium.
- MGPT Museo di Geologia e Paleontologia, Università di Torino, Italy.
- MGR Museo di Geologia, Roma, Italy.
- MHNBx Muséum d'Histoire naturelle de Bordeaux, France.
- MNHN Muséum National d'Histoire Naturelle, Paris, France.
- MSNG Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy.
- MZB Museo di Zoologia dell'Università di Bologna, Italy.
- NHMW Natural History Museum Wien, Austria.
- RGM Naturalis Biodiversity Center, Fossil Mollusca collection, Leiden, The Netherlands.
- SMF Senckenberg Museum, Frankfurt, Germany.
- AC A. Cluzaud collection, Pessac, France.
- BD B. Dell'Angelo collection, Genova, Italy (will be housed in MZB).
- DA D. Aucoin collection, Signy-Signets, France
- JFL J.-F. Lesport collection, Sainte Hélène, France.
- JVC J. van Cuyck collection, Lège-Cap-Ferret, France
- PR P. Renard collection, Beauzelle, France

## Geological and geographical settings

The Aquitaine Basin is situated on the Atlantic front of Western Europe.

From its formation in the Triassic until today, this basin was filled with sediment from erosion of the Armorican Massif in the north and the Massif Central and the Black Mountains to the east and south by orogeny of the Pyrenees in the early Paleogene.

Early Tertiary to middle Miocene (Serravallian) this basin is filled with marine sediments in which the Polyplacophora described herein were collected, mostly in faluns.

The reader may refer to Georges Lecointre (1947) for explanations on the history and the formation of the Ligerian Basin.

## Overview of outcrops in the Aquitaine and Ligerian Basins

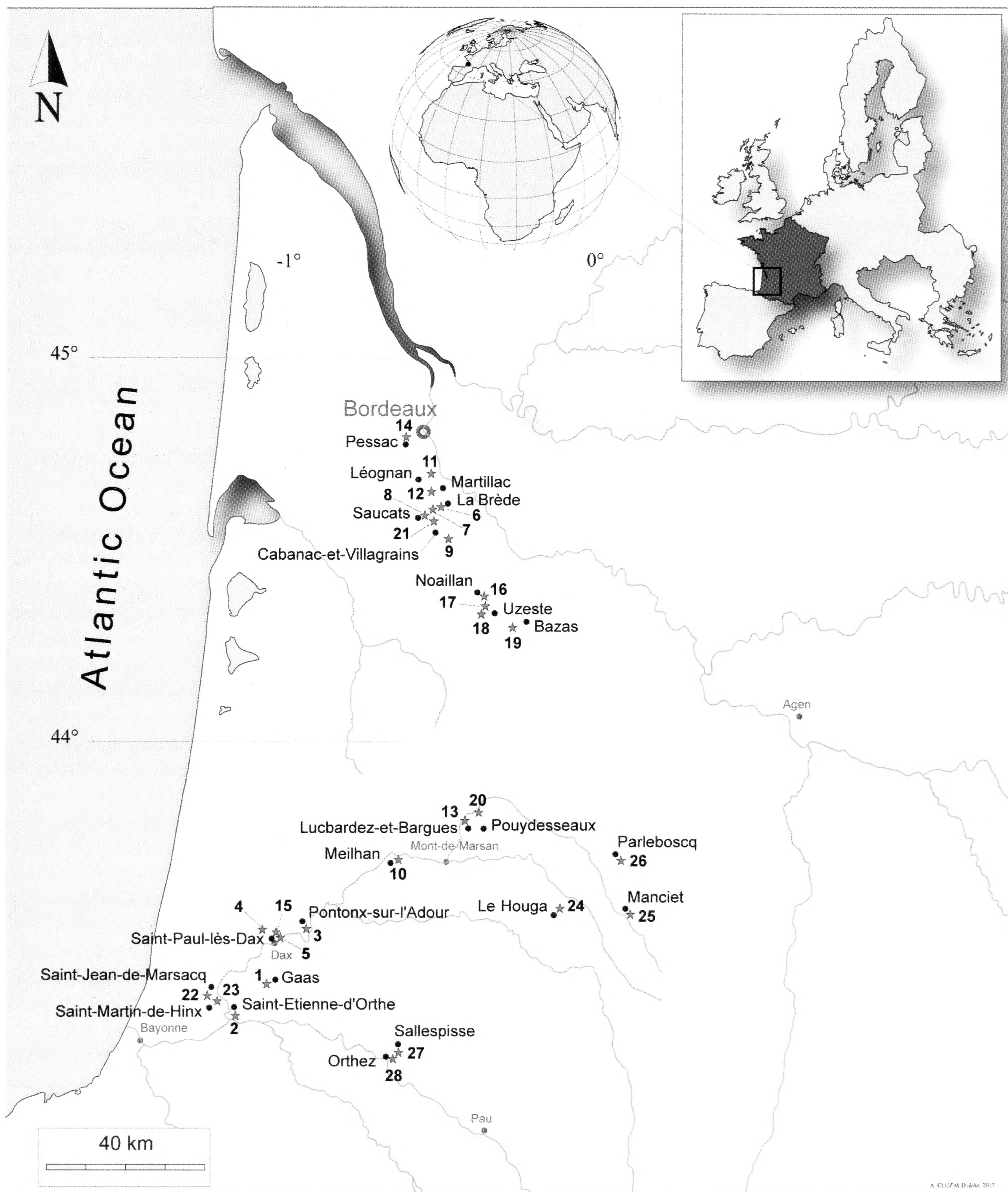
A historical, bibliographical first authors (but not exhaustive), geological and geographical description of the Aquitaine Basin sites yielding of Polyplacophora species in the Aquitaine Basin is presented (Fig. 1A).

### Oligocene (Rupelian)

- Gaas (Landes): Espibos, Lagouarde, Larrat

The municipality of Gaas is located 15 kilometers south of Dax, Chalosse area. The Rupélian marine sediments





**Fig. 1A.** Study area and sites location of the Aquitaine Basin.  
(1: Espibos, Lagouarde, Larrat; 2: Ruisseau de l'église; 3: Mineur; 4: Abesse, Estoti; 5: Maïnot; 6: Moulin d'Augey; 7: Ninon; 8: Lariey; 9: Pouquet; 10: Carrière Vives; 11: Le Thil; 12: Coupe du fossé près de La Solitude; 13: Petit Barges; 14: Lorient; 15: Cabanes; 16: Cachac; 17: Gamachot; 18: Les Auguillères; 19: la Flotte; 20: Maureilhan; 21: Peloua; 22: Lahitet; 23: Bordepouy; 24: carrière Gélis; 25: Pouyouet; 26: la Guirande; 27: Carré; 28: Le Paren).

**Fig. 1A.** Area di studio e ubicazione dei siti del bacino Aquitaniano.

of Gaas are of transgressive type and were deposited in a small Oligocene Gulf placed within the Gaas syncline, bounded on the north by the Tercis anticline and south by the ride of Biarrotte. The infra-littoral levels of Gaas consist of mostly clay faluns (i.e. a friable bioclastic marine deposit, sometimes partly consolidated, with a sandy or clayey-sandy matrix) or bioclastic clays. The

majority of valves of Polyplacophora were collected from the sediment retained inside the largest shells. (e.g. *Oostrombus*, *Ampullinopsis*, *Heteroninella* and other) in which the microfauna has been trapped and protected from swell and damaging ocean currents. Known since the eighteenth century, many authors (Borda d'Oro, Basterot, Grateloup, Tournouër and others) have



contributed to the knowledge of the deposits in Gaas area. The Espibos and Lagouarde levels are part of SBZ21 biozonation, and Strontium isotopes (Sr) provide an estimated age of 31.6 Ma for Espibos (Cahuzac & Janssen, 2010). For more information refer to Lesport et al., 2015.

The outcrops at Larrat (and Tartas) were once widely exploited for their mineral wealth and numerous fossil levels very diverse facies have been extracted (Grateloup, 1827; Delbos, 1848, 1854; Tournouër, 1863; Benoist, 1884; Daguin, 1937, 1948). These sandpits, stone quarries and clay pits have dramatically changed the landscape of this valley making the land unsuitable for farming.

Today, after long work leveling and filling these excavations which could reach several 10s of meters deep [pers. com. Mr. Claude Tastet to one of us (AC)] there is almost no visible outcrop, replaced by crops and forest plantations. These works were carried out between 1965 and 1970 initially and the last (most important) excavation was refilled in 1985.

Recent investigations in these areas helped find and exploit beige to gray faluns, more or less clayey, that overlie a major series of increasingly compact blue marl clays.

Many polyplacophora valves were collected in these sands with abundant fragmented branching corals and more specifically in the sand filling from shells, trapped in the largest gastropods.

## Oligocene (Chattian)

- Saint-Etienne-d'Orthe (Landes): Ruisseau de l'église  
The Ruisseau de l'église deposit is located in the commune of Saint-Etienne-d'Orthe in the southeast of the village church. The fossiliferous marls of Saint-Etienne-d'Orthe are part of the original filling of the Saubrigues palaeo-canyon formed at Rupélien (Kieken, 1973). The Chattian filling contains faunas from the upper bathyal zone (Lozouet, 1986).

During the 19<sup>th</sup> century, various authors, from Grateloup to Raulin, contributed to the knowledge and to an alternative stratigraphic positioning of these sedimentary levels. Recent isotopic dating attributes a Chattian age of 25.3 Ma according to Cahuzac & Janssen, 2010. For more information refer to Lesport et al., 2015.

- Pontonx-sur-l'Adour (Landes): Mineur  
Situating on the commune of Pontonx-sur-l'Adour, the Chattian outcropping of Mineur leaning on the north side of the Triassic Dome of Thetieu was studied by Cahuzac (1980) and Lozouet (1986). The Chattian level of bluish gray sands located in the upper part of the cross section (Cahuzac, 1980) yielded some individuals of Polyplacophora.

This falun has been dated to the NP25 (Müller & Pujol, 1979; Cahuzac et al., 1995), P22 and SBZ23 zones (Cahuzac & Janssen, 2010). For more information refer to Lesport et al., 2015.

- Saint-Paul-lès-Dax (Landes): Abesse, Estoti  
The series of outcrops in the valley of Poustagnac repre-

sented by "les faluns d'Abesse" on the commune of Saint-Paul-lès-Dax belong to the Chattian. These outcrops are positioned on the Northeast of the Sebastopol-Souston anticline. The Abesse left bank (Abesse RD) and Estoti levels were dated respectively, to 24.6 Ma according to Cahuzac et al. (1997) by <sup>87</sup>Sr/<sup>86</sup>Sr isotope analysis, and the P22, SBZ23 zones (Cahuzac & Poignant, 1997), Pteropod area 16b (Cahuzac & Janssen, 2010). These faluns are composed of sand and limestone shells, rich in molluscs and scleractinian corals of infralittoral biotop. For more information refer to Lesport et al., 2015.

## Miocene (Aquitania)

- Saint-Paul-lès-Dax (Landes): Maïnot  
In the Adour Basin, the deposits of Aquitanian age deposited on the northeast flank of the Dome of Dax, at the entrance of a gulf that advances towards the south. The Maïnot deposit lies to the east of the commune of Saint-Paul-lès-Dax. The gray-pink to yellow fossil deposit is composed of a very shelly sandy falun, numerous pebbles and abundant scleractinian corals. The site today, known since the nineteenth century, disappeared under the road infrastructure. Brongniart and Grateloup were the first to study the site. Cahuzac & Janssen (2010) places this deposit in the biozones N4, SBZ24 and 17a. The study of molluscs confirms the positioning of these sites in the Aquitanian (Lozouet & Maestrati, 1994; Dolin & Lozouet, 2004; Cluzaud et al., 2014). For more information refer to Lesport et al., 2015.

- La Brède (Gironde): Moulin d'Augey  
The fossiliferous outcrops of the Moulin d'Augey are located in the Saucats valley in the commune of La Brède. They are part of the stratotypical series of the Aquitanian defined between La Brède and Saucats in 1858 (Mayer, 1858). This part far downstream from the valley would correspond to the Moulin du Battant in the description of Charles Mayer.

A recent and detailed study by Cahuzac et al. (2012) covers about 20 outcrops currently visible along the stream. The different facies are described and a list of molluscs is given. The outcrop Sc44 (*in* Cahuzac et al., 2012), located on the right bank upstream of the mill, is visible only when the mill's lock is open. A falun of yellowish shell sand has delivered only a few valves of polyplacophorans. For more information refer to Cahuzac et al., 2012.

- La Brède (Gironde): Ninon  
In the Saucats valley, further upstream from the previous site, a new outcrop (Ni 4 *in* Cahuzac et al., 2012) was discovered during field investigations for studies on the Aquitanian Stratotype. It is located in a small valley that is fairly contiguous on the left bank of the Saucats stream a little upstream from the Moulin du bois Pertus [= Partus (Mayer, 1858)]. A few meters above the Saucats stream, very shelly bioclastic blue sands at the base of an indurated and lithophagous lev-



el are observable on the left bank of the small stream which takes its source a few hundred meters from the hamlet of Ninon. The mollusc fauna was listed by Cahuzac et al. (2012), and the faunal assemblage corresponds to several coastal marine environments accumulated in a coastal thanatocoenosis. For more information refer to Cahuzac et al., 2012.

- Saucats (Gironde): Lariey

Jouannet (1823), de Basterot (1825), and Guillard (1826) described different outcrops observed in the area of the Lariey hamlet and some molluscs without ever mentioning this place. Delbos (1848: 424) seems to be the first to mention the existence of this deposit under the name of Larrieg. The same name Larieg is used by Mayer (1858) when describing the Aquitanian stratotype. Tounoüer (1862), Linder (1872) and then Benoist (1873) draw up the first lists of molluscs and describe the site with the toponym Lariey. This locality is also spelled l'Ariey (IGN PESSAC 1: 25000 n° 1537 WEST). More recently, a detailed study of molluscs was carried out by Lozouet et al. (2001, 2003)

On the right bank of the stream, one can observe limestone sandstones, sands, and faluns more or less clayey and with calcareous fossis, which succeed several meters thick. The upper horizons correspond to lagoonal environments and terminate in a lacustrine level. From an open sea fauna at the base of the series visible at the museum site, one passes to an open bay fauna then an isolated environment and finally a withdrawal of the sea replaced by fresh waters. Currently the Lariey site museum built on the commune of Saucats (Gironde) (00° 33'52,8"- 44 ° 39'20,6"), managed by the Association of the geological Saucats-La Brède. The polyplacophoran valves come mainly from the *Perna aquitanica* (Mayer, 1858) layer, level 8 (Cahuzac et al., 1996). This level is characterized by an accumulation of connected *Perna* shells associated with a malacofauna characteristic of an open bay environment and tropical climate. Level 8 has undergone little post-mortem transport, unlike level 6 (Cahuzac et al., 1996) whose organisms come from different environments (Rocher & Lesport, 2005). Lariey's stratotypical deposits belong to the summit of the Aquitanian of the Saucats valley. This falun was attributed to the NN1 zone (Müller & Pujol, 1979). Cahuzac & Janssen (2010) placed at level 6 (Cahuzac et al., 1996) in the marine biozone N4 and SBZ24 and in the Pteropod area 17a. The age of level 8 in *Perna* is estimated to be 20.42 Ma by <sup>87</sup>Sr / <sup>86</sup>Sr "GTS 2004" isotope analysis (Londeix et al., 2014).

- Cabanac-et-Villagrains (Gironde): Pouquet

In 1823, Jouannet (p. 87) indicated the presence of fossils near the village of Cabanac and in the surrounding communes. The outcrop of Pouquet is indicated by Tournouër (1862), Mayer (1867), Fallot (1889) and other. The exposures are on the banks of a small stream that flows into the Gat-Mort on the right bank. On a lime sandstone lays sandy orange yellow clay which corresponds to an infralittoral coastal deposit. At the base,

on the sandstones, the clay falun contains an association of molluscs dominated by gastropods of lagoon biotope. This level is surmounted by very shelly sands which contain amongst others numerous bivalves of open bay environments. These deposits of transgressive type have accumulated on the northern flank of the anticline Villagrains / Landiras, land in the early Miocene. The biotopes and mollusc communities are similar to those of Lariey. More than 90% of the Pouquet malacofauna is present at Saucats Lariey (JFL observations). We consider that these deposits are part of the Aquitanian series (Cluzaud et al., 2014).

## Miocene (Burdigalian)

- Meilhan (Landes): Carrière Vives

The ancient quarries exploited for at least two centuries and the present ones (carrières Vives) are situated at an altitude of about 30 meters on both banks of the Midouze River, in a zone at the junction of three communes of the Landes (Saint-Martin-d'Oney, Campagne and Meilhan). These deposits were signaled by Jacquot & Raulin (1888) who situated them in the middle Miocene of Mont-de-Marsan, and Daguin (1948) considered them related to the calcareous sandstone of the "Helvetian" (middle Miocene). Poignant (1967) and Capdeville (1990) dated these beds to the early Miocene. A first list of their molluscs was given by Cluzaud & Lesport (in Capdeville, 1990). From 1993 on, several authors, such as Lozouet, Cahuzac and Chaix (cf. Michel et al., 2012 for a more complete list of these authors) and Cluzaud & Cahuzac (2006) have started to list and describe the rich fauna of this site.

Cahuzac & Turpin (1999) accepted an late Aquitanian age for a bed in the quarry at the base of the marine shell layers. Lozouet et al. (2001) proposed an Aquitanian age for the faluns of this quarry. Waiting for a dating of the whole stratigraphical series of the quarry and basing ourselves on the study of marine Miocene molluscs, Lesport et al. (2015) proposed a basal Burdigalian age for a great part of faluns deposits, corresponding probably to the very first eustatic transgressive oscillation of the Burdigalian in the Aquitaine Basin. For more information refer to Lesport et al., 2015.

- Léognan/Martillac (Gironde): Le Thil

To the best of our knowledge, the oldest bibliographic reference mentioning the geology of the locality of Le Thil (Léognan) is by Brochon (1864). Fallot (1895) and Degrange-Touzin (1896, 1897) describe several Aquitanian and Burdigalian outcrops to the south of the château of Le Thil.

The faluns of Le Thil are located south of the château on the banks of Bourran Stream, which delimits the two communes Léognan and Martillac (Gironde), and also on the banks of some of its tributaries. The outcrops are discontinuous over a distance of 1.5 km at an altitude between 22 and 45 m. The Rupelian limestone crops out near the château, then the Aquitanian beds are seen 200 meters south of the château and the Burdigalian beds



crop out another 400 meters further south of the Aquitanian beds. Cahuzac & Turpin (1999) determined an Aquitanian age of 21.9 Ma for one of the sites of Le Thil based on  $87\text{Sr}/86\text{Sr}$  isotopic analysis.

Samples were taken by two of us (J.-F. Lesport & A. Cluzaud) at three points on the banks of Bourran Stream (Thil 1-3). Le Thil 1 has an Aquitanian fauna; the faunas of Le Thil 2 and 3 are more like the subtropical to tropical Burdigalian communities. Outcrop Le Thil 2 is situated about 1 km from the château, on the left bank of the main stream at an altitude of about 33 m, near the junction with a tributary. Some valves of Polyplacophora are discovered in this sample. (For more information refer to Lesport et al., 2015).

- Martillac (Gironde): Coupe du fossé près de La Solitude

This cross section is located in a very deep ditch dug on the left bank of the stream of Martillac/Le Breyra, about 500 meters northwest of the convent of la Solitude in the commune of Martillac. It could be observed by means of drainage works for vineyards, carried out in the course of the 2000s.

At the base of the cross section the sediment is gray, sandy, fine, compact, with very few shells visible. Then succeeds a finely sandy carbonated sequence, blue gray, in which are observed some beds shells very thin. It is in these beds of accumulations of marine fauna composed mainly of bivalves (*Microloripes*, *Donax*, *Psammotreta*, *Pitar*, *Macra*...) that the rare polyplacophora valves were collected. The malacofauna little transported, corresponds to a biotope of a sheltered bay beach under tropical climate. Lesport & Cahuzac (2005) places these sands in the SB25 biozone at the Burdigalian base.

- Lucbardez-et-Bargues (Landes): Petit Bargues

The beds of Petit Bargues (Lucbardez-et-Bargues) belong to the Faluns of Saint-Avit. The outcrops at Lucbardez-et-Bargues are part of the series of outcrops that was sampled by Perris in 1851 (Noulet, 1854: 83). Delbos (1848, 1854) and Noulet (1854) mentioned the presence of freshwater limestone between the marine layers at Lucbardez-et-Bargues. Benoist (1884a) published a list of the molluscs collected at Lucbardez-et-Bargues by du Boucher and visited the site with Dubalen (Benoist, 1887). Fallot (1896) discussed the stratigraphical position of the faluns of Lucbardez-et-Bargues and Saint-Avit. Degrange-Touzin (1912) described with high precision several outcrops in the Douze valley, including that of Petit Bargues, for which he gave an important list of marine organisms. Cossmann & Peyrot figured and described in their C. N. A. some molluscs from Petit Bargues (= Cantine de Bargues in C. N. A.) from the collection of Degrange-Touzin. A cross-section of Petit Bargues was published in the notes to the Carte Géologique de la France (Karnay, 1990). Cahuzac et al. (1993) cited this site in the comparative study of a genus of Bivalvia. From this site, Lesport & Cahuzac (2002) revised a species described by Grateloup in 1845.

The beds at Petit Bargues are situated in the commune

of Lucbardez-et-Bargues (Landes). The outcrop is on the banks of the stream known as "Ruisseau des neuf fontaines", which flows into the River Douze. At an altitude of 40-50 meters, several beds of marls, faluns, lignite, limestone and calcareous sandstone make up a thickness of 8 meters. Historically, the faluns of Saint-Avit have all been classified in the Aquitanian. Recently, the observation of miogypsines (Foraminifera) by Cahuzac (in Lesport & Cahuzac, 2002) provided a basal Burdigalian age for the middle part of this section. The fauna collected is of tropical to subtropical type. Several molluscan communities (mainly marine), some in blended and disturbed deposits, belong to marine or brackish biotopes, in a few places together with scleractinian corals and small pebbles in lower beach accumulations. Some specimens of Polyplacophora were collected in levels 6 to 8 of the section of Karnay (1990) characterized by the abundance of *Sunetta aturi* (Mayer, 1858a). For more information refer to Lesport et al., 2015.

- Pessac/Mérignac (Gironde): Lorient

Jouannet (1839) was one of the first authors to report the presence of fossils in the commune of Pessac. Delbos (1848) states that the "fahlun de Mérignac" is unearthed on several points of the commune of Pessac. It was only in the late nineteenth and early twentieth centuries that some amateurs exploited and described the rich faunas of outcrops located upstream and downstream of the Lorient bridge. It is several hundred meters on the banks of Le Peugeot stream that separates the municipalities of Pessac and Mérignac that one can observe different levels. Fallot (1895), Degrange-Touzin (1899) and Neuville (1899) listed the fauna and the various sites they visited in the valley of the Peugeot (Pessac Lorient, Noès). Sylvestre de Sacy (1926) publishes a synthesis at the XIIIth International Geological Congress of 1922 in Belgium. Thanks to the collections available to them, Cossmann & Peyrot (1909 - 1935) in the C. N. A. cite, describe and figure out several species of molluscs from the deposits of this valley. More recently, the lowest levels east of the Lorient Bridge have been dated 22.2 Ma (Aquitanian) by  $87\text{Sr} / 86\text{Sr}$  isotopic analysis and the author cites Lorient levels as typical Burdigalian (Cahuzac, 2009). The malacofauna of this site comparable to those that can also be collected in the sites of Léognan (Thibaudeau), Mérignac (Pontic pars, Baour pars), Meilhan (Vives quarry), Saint-Paul-lès-Dax (Cabanes) representative of the early Burdigalien region. The faluns of Pessac (and Mérignac) are represented by very shelly sands, locally accumulated several meters thick. Today they are largely masked by the agglomeration. All the Polyplacophora valves were collected in upper levels, most probably Burdigalian. More generally, these faluns, those of Saint-Médard-en-Jalles and Haillan are part of a large deposit zone of the early Miocene, the northernmost of Aquitaine. The faunas and deposit structures at these levels are fairly comparable, but the boundary between the Aquitanian and the Burdigalian in this area is still not precisely identified.



- Saint-Paul-lès-Dax (Landes): Cabanes

In the eighteenth century, the learned Jacques-François Borda d'Oro (1718-1804) frequented in his youth age and regularly the deposit of Cabanes. He described in some of his unpublished manuscripts the fruit of his harvests of the tertiary sites of Saint-Paul-lès-Dax of which Cabanes is the most quoted (Odin, 2004). In 1808, Brongniart had already visited this outcrop for the second time (Brongniart, 1834) and named this site Moulin de Cabanières. Boué (1824), Grateloup (1827), Deshayes (1832), Delbos (1848) and many others throughout the last two centuries have referred to the rich marine fauna of the faluns of Cabanes, which are also noted *in litteris* with the following alternative spellings: Cabane, Cabannes or Moulin de Cabanes.

The range of fossiliferous deposits around the Cabanes mill is extensive. It is bordered to the south by the area of Mainot and to the north-north-west by that of Mandillot. Numerous quarries, marl pits and excavations have been dug over time in this area but no cross section has been published (Pressouyre, 1936). Our collections (made in the 1980s) come from excavations practiced on the one hand in a land located near a small market gardening near the locality called l'Eglise and on the other hand a road ditch to the east of the Cabanes mill. It was then possible to observe the following fossiliferous cross section at a height of about 1.5 m.

A gray-pink falun with numerous molluscs was settled locally on an undetermined thickness deposit, compact, not very sandy, composed mainly of flat pebbles and containing rare mollusks often rolled. Above, a yellowish falun with many large scleractinian corals and reef malacofauna also contains many reworked elements of the underlying levels. Then a level of fine yellow sand with accumulations of shells and rare scleractinian corals ends the visible marine series.

The molluscs of these faluns are of the stenohaline type, coming from tropical coastal environments, of coral coastal fringes open sea to protected bay. Cahuzac & Janssen (2010) established a correspondence of this site with the biozones N5, NN2, lower SBZ25 and 17b of early Burdigalian age.

- Noaillan (Gironde): Cachac

The site is located on the commune of Noaillan at the place called Cachac, in a field, on the level curve of the 55 m, a flush yellow or white falun alternates with parts of shell limestone. The malacofauna, accompanied by a rich fauna of scleractinian corals comes from a coral biotope dismantled. The presence of numerous molluscs common to the faluns of Saint-Avit [e.g. Lucbardez, (Petit Bargues), Meilhan (Vives quarry)] and other early Miocene sites [e.g. Noaillan (Gamachot), Saint-Paul-lès-Dax (Cabanes)] allows us to place this outcrop in the Burdigalian period. The abundance of Miogypsins of large sizes characteristic in this site confirms this stratigraphic position.

- Noaillan (Gironde): Gamachot

Chaubard (1838), Raulin (1848), Tournouër (1862),

Linder (1872) were the first to cite the fossiliferous levels of the Villandraut area, but it was not until the end of the 19<sup>th</sup> century that Benoist (1889) and Reyt (1890) make known the deposit of Gamachot. The site is regularly visited and studied during the 20<sup>th</sup> century.

In the valley of the Font de la Lève stream, from the downstream of the mill of Gamachot up to several hundred meters upstream of the mill of Fortis, one can observe faluns, sands, limestones that flush locally on both bank which belong respectively (in this zone) to the communes of Noaillan for the right bank and Uzeste for the left bank.

In Gamachot the base of the cross section visible today on the left bank is composed of a white lacustrine limestone breccia. A little higher up on the right bank, a *Hyotissa undata* (Lamarck, 1819) level is surmounted by a sandy blue falun fossiliferous. In this one many valves of polyplacophora have been collected. At the top, a sandy clay level of more than a meter essentially composed of accumulated branchy scleractinian corals (*Porites* Link, 1807).

The stenohalin marine fauna is tropical, originating from a protected bay in an infralittoral zone. The malacofauna is close to that of the sites of Lucbardez (Petit Bargues), Meilhan (Vives quarry), Noaillan (Cachac), Saint-Paul-lès-Dax (Cabanes) and Mérignac / Pessac pars. Cahuzac et Janssen (2010) link this site to the basal Burdigalian, N5 / NN2 / SBZ25 / 17b biozones.

- Uzeste (Gironde): Les Auguillères

Tournouër (1862), Linder (1868), Benoist (1878) were the first authors to report the faluns of Uzeste. To the west of this village, along the stream of the settlement, a series of faluns and limestone beds are visible on the banks. The falun where the polyplacophora valves are found is yellow to white, consisting of loose sand containing a shallow sea reef fauna, accompanied by echinoderms (*Parascutella* Durham, 1953). This fauna has great affinities with the levels of Noaillan (Gamachot, Cachac) close geographically but also with those of Meilhan (Vives quarry), Lucbardez (Petit Bargues) and Saint-Paul-lès-Dax (Cabanes). These faluns deposited during the first Burdigalian periods.

- Bazas (Gironde): la Flotte

The lacustrine shell limestones and the oyster clays at Bazas are succinctly described in 1823 by Jouannet, Ferrussac and then Chaubard (1833). In 1848, Delbos, Raulin defined the faluns of Bazas, but the deposit of la Flotte at Bazas that we have not found, is reported and described for the first time in 1889 by Degrange-Touzin. To the west of the house la Flotte, during the works of the N 524 for the bypass of the town of Bazas in the 1980s, a fossiliferous level was temporarily brought to light. After the bridge which crosses the road of Calonge in the direction of Captieux, in the bottom of the slope, below the level curve of 100 meters, on 50 centimeters of height it was possible to observe and to sample a greyish falun consisting of a coarse sand containing many marine molluscs more or less well preserved. The



presence of Pectinidae (*Pecten ziziniæ* Blanckenhorn, 1903) identified by Bongrain (1992) and tropical malacofauna comparable to that of Noaillan (Gamachot) places this site in the early Burdigalian period. A single polyplacophora valve was collected in this deposit.

- Pouydesseaux (Landes): Maureilhan

The layers of Maureilhan, commune of Pouydesseaux belong to the Faluns of Saint-Avit. Numerous fossiliferous levels occur on the banks of the Douze valley between Roquefort and Saint-Avit. The outcrops of Maureilhan are located 1 kilometers north-northeast upstream of the famous deposit of Moulin de Carro, mainly on the left bank. Exploited since the 1980s by many amateur palaeontologists, this deposit has not been the subject of any study. It is a sandy falun, yellow or gray beige, very shelly, over a thickness of about 1 meter. It covers in places on a non-continuous hard substrate with "faults" in which numerous shells have accumulated. At the summit, a clayey compact gray clay level contains in abundance *Turitella terebralis* Lamarck, 1822 and *T. desmaristina* de Basterot, 1825 in perfect conservation.

Under tropical climate, an infralittoral malacofauna, scleractinian corals and remains of marine mammals were deposited in a calm environment. The malacofauna is close to that of the Pouydesseaux (Moulin de Carro) or Saucats (Peloua) deposits. We place this deposit in the Burdigalien.

- Saucats (Gironde): Peloua

In the early Burdigalian, the Saucats region was part of a gulf that was limited to the south by the anticline of Cabanac-Villagrain. The Le Peloua site was discovered by Delfortrie around 1869 (Benoist, 1884b). This outcrop was the subject of several notes by Benoist (1884b, 1885, 1887a, 1888). Degrange-Touzin (1893, 1896a, 1899a) listed the numerous species found at this site and Fallot (1889a, 1889b, 1889c, 1895) discussed the stratigraphical and chronological position of this site. Cossmann & Peyrot in the C. N. A. described and figured the numerous molluscs from Le Peloua in several local collections. Other authors, e.g. Dolfuss (1909), Chevalier (1961), Magne & Vergneau-Saubade (e.g. 1973, 1973a, 1975), Steurbaut (1981), Cahuzac et al. (1993), Lozouet & Renard (1998), Cahuzac & Janssen (2010), Carriol et al. (2011) and others have contributed to the knowledge of marine organisms of le Peloua. This site has often been taken as a reference for the stratigraphy and the definition of the Burdigalian stratotype (e.g. Depéret, 1892; Fabre, 1939; Ringeade, 1978; Londeix, 1991; Cahuzac et al., 1996, 2003 and others). Three sections have been published by Cahuzac et al. (1996, 1997, 2003). Using a foraminifera-based biostratigraphy method, Gourinard et al. (1985) established an age of  $20.6 \pm 0.15$  Ma, and by  $87\text{Sr}/86\text{Sr}$  isotopes, Cahuzac et al. (1997) attributed an age of 20.2 Ma to the scleractinian corals falun, and 20.4 Ma to the base level.

The site museum of Le Peloua is now established in the commune of Saucats (Gironde) ( $44^{\circ}39'20.6''\text{N}$ - $00^{\circ}33'$

$52.8''\text{W}$ ) and is managed by the Association of the geological reserve of Saucats-La Brède.

The bed where Polyplacophora were collected is a falun consisting of a fine yellowish orange sand, of pebbles with lithophagine boreholes, of scleractinian corals and of molluscs corresponding to a stage of the marine Burdigalian transgression (level j' of the section by Cahuzac et al., 1996). The faunas of this bed are of subtropical to tropical type, in an infralittoral coastal biotope, transported from a nearby zone of fringe corals patches. For more information refer to Lesport et al., 2015.

- Saint-Martin-de-Hinx (Landes): Lahitet

The gray-blue marls of Saint-Jean-de-Marsacq (Landes) and Saint-Martin-de-Hinx were deposited in the Miocene in the Saubrigues paleocanyon, filling to the west of the Adour part of this pit over several meters thick. Former fossiliferous marls quarry dominate the place called Lahitet (or Lahitète) near the Adour. These gray marls contain some molluscs accumulated in orange sandy lenses disseminated in the mass of the circallittoral muds. Malacofauna and plant debris come mainly from coastal zones of tropical climate, mixed with a circallittoral biotope.

Delbos (1848) attached the marls of Saint-Jean-de-Marsacq to the Burdigalian, then changed his mind in 1854 by placing them in the middle Miocene. As early as 1858 Mayer ranks these deposits in the Tortonian, a stratigraphic position that will be maintained by several authors including Cossmann & Peyrot in C. N. A. until the first third of the twentieth century. It was not until 1951 that Vigneaux and Magne brought together the malacological and bryozoological fauna of this region in Burdigalian. More recently, Cahuzac & Janssen (2010) confirmed the positioning of Lahitet in the late Burdigalian from 17.4 Ma by analyzes of  $87\text{Sr} / 86\text{Sr}$  isotopic ratios and correlated this dating with NN4 and N6 pars-N7 biozones.

- Saint-Martin-de-Hinx (Landes): Bordepouy

A gray marl rises several meters thick along la route des barthes which leads from the Adour to the village of Saint-Martin-de-Hinx (Landes). This outcrop near the Lahitet marl quarries is situated at a substantially equivalent altitude (~ 50 level curve). The malacofauna dispersed in the mass is fairly diversified, marine, stenohaline and tropical. The affinity of the malacofauna between Lahitet and Bordepouy, their altitude and their similar lithology in a context of filling the same paleocanyon makes it possible to link this site also to the late Burdigalien.

## Miocene (Langhian)

- Le Houga (Gers): carrière Gélis

This fossil-bearing level was discovered in the 1980s by Jacques Faullumel in a quarry of the tile/brick factory Gélis situated north-east of the village of Le Houga. During the preparation of a new edition of the geological map of this area (Carte géologique de la France à



1/50 000, feuille 952 Nogaro) a first section of the quarry was drawn by Capdeville (1991), showing two distinct stages [Burdigalian (continental) and Serravallian (marine)].

After a campaign of emergency diggings, a list of fossil molluscs from the lower marine level of this section was established by A. Cluzaud and J.-F. Lesport (in Capdeville, 1991). A terrestrial mammal's tooth collected in the upper levels (Serravallian) by one of us (A. Cluzaud) was studied by Cahuzac & Tassy (1999). In 1995 Cahuzac et al. distinguished two distinct marine phases (Langhian and Serravallian). The study by Ducasse & Cahuzac (1996) of the ostracods identified the different beds (continental to marine) of this quarry. Cahuzac & Poignant (2000) presented a more precise section of this Miocene succession, discerned three stages in the quarry (Burdigalian, Langhian and Serravallian) and correlated the lower marine bed of this section with planktonic zones N8-N9 and NN5 (Langhian).

Le Houga is a commune of the Bas-Armagnac (Gers); the beds revealed in this quarry are at an altitude of between 100 and 120 meters. The Langhian deposits observed in the quarry correspond to relatively calm marine and brackish-water environments. They were deposited in the southwest of the gulf of Manciet-Baudignan, in the infralittoral zone. This rich and diversified subtropical to tropical malacofauna is similar to that of Manciet. In the marine shell sands at the base of the marine beds a polyplacophora valve was discovered (sequence II, "falun jaune à roux, à galets" of the section in Cahuzac & Poignant, 2000). For more information refer to Lesport et al., 2015.

- Manciet (Gers): Pouyouet

Manciet (Gers) is a commune situated on one of the hillsides of Armagnac, in the Douze valley. The outcrop is situated near the village at an altitude of between 125 and 130 m, near the Pouyouet farm. The whole of the Faluns of Armagnac is located in the eastern central part of the Aquitaine Basin. During the Langhian, the shell sands of Manciet were deposited in the southern part of the Manciet-Baudignan gulf (Cahuzac & Poignant, 2000). The beds at Pouyouet (Manciet) are part of the formation known as the Faluns of Armagnac. Since 1848, Raulin cited Manciet for its oyster conglomerates and later for its faluns (Raulin, 1856), then Jacquot (1870) and Lartet (1873) followed. Cossmann & Peyrot (1913, 1914) published in the C. N. A. numerous molluscan species found in Manciet during excavations from 1912 by Peyrot with Cossmann and then with Barrère, Duvergier and Neuville (Peyrot, 1913, 1923). Astre (1922, 1923) also described some new mollusk species. Peyrot published three notes on the falun of Manciet (1913, 1923, 1933) in which he entered into detail on the history of geological studies, the stratigraphy of the commune and the paleontological study of the site. He confirmed the synchronism of the Faluns of Armagnac and those of the Loire Basin demonstrated by Tournouër. This was followed by several scientific studies (e.g., Crouzel, 1957; Crouzel et al., 1989; Cahuzac et al., 1995;

Ducasse & Cahuzac, 1996; Duranthon & Cahuzac, 1997; Poignant et al., 2000; Chaix et al., 2001). A section of the site was established by Cahuzac & Poignant (2000). The site of Manciet was dated to 16 Ma  $\pm$  0.26 by Magné et al. (1985), which gives it a Langhian age, confirmed by Cahuzac et al. (1995) who attributed it to the biozone NN5.

The malacofauna is of subtropical to tropical type during the transgressive period, as attested by the presence of scleractinian corals. The marine organisms were transported; the presence of numerous rolled pebbles corresponds to a littoral deposit in an agitated environment. For more information refer to Lesport et al., 2015.

- Parleboscq (Landes): la Guirande

Tournouër (1873) defines the stratigraphic position of the falun of la Guirande deposit (today this toponym is spelled la Guironde on the topographic map of the Institut Géographique National, or Laguironde for the agricultural farm located in the commune of Parleboscq, which he cites for the first time. In 1874, in a note on the fossiliferous deposits of the environs of Sos (Lot-et-Garonne) and Gabarret (Landes), he drew up a list of the principal fossils of this marl quarry. Benoist (1883) also mentions the presence of the *Ostrea gingensis* (Schlotheim, 1813) [*Crassostrea gryphoides* (Schlotheim, 1813)]. Jacquot & Raulin (1888) also mention the exploitation of marl of la Guirande farm, whose falun counts the largest number of mollusc species around Gabarret. Subsequently, many species of fossils of this margin were described and figured in C. N. A. The fossiliferous level is in the form of a beige colored marly sand. This ensemble, with a visible thickness of 1.20 m, covers a fossiliferous compact gray-blue marl of unknown thickness. The ostracofauna indicates a shallow marine environment, subjected to brackish influences (Ducasse & Cahuzac, 1996) in agreement with the presence of lagoon foraminifera (Cahuzac & Poignant, 2000). A few polyplacophora valves were found in these inshore marine deposits. This marine level is dated from the middle Miocene [15.2 to 14.2 Ma according to the method used (Cahuzac & Poignant, 2000)].

## Miocene (Serravallian)

- Sallespisse (Pyrénées-Atlantiques): Carré, Orthez: Le Paren

The outcrops of Sallespisse (Carré) and Orthez (Le Paren) are part of the Miocene series of the Blue Faluns. Sallespisse and Orthez (Pyrénées-Atlantiques) are villages in the north of Béarn, canton of Orthez, at the foot of the Pyrénées, at the borders of the Chalosse area. During the Serravallian, the sea expanded the gulf of Chalosse, which is limited by the "Diapir de Dax", the "Ride de Tercis" and the "Dôme de Clermont" on one side, and the anticline of Louer on the other, and penetrated further south, constituting the Gulf of Orthez/Salies-de-Béarn. Some authors (Degrange-Touzin, 1895; Balguerie, 1884; Daguin, 1948) have signaled several sites for fossils in communes of Sallespisse (e.g. Carré)



and Orthez, positioned on a straight line NE to SW. The study of benthic foraminifera and also that of ostracod associations completed with strontium analyses (Cahuzac & Poignant, 1996; Ducasse & Cahuzac, 1997) suggested a Serravallian age for the Faluns of Orthez and Sallespisse. For more information refer to Lesport et al., 2015.

### Late Miocene

- Amberre (Vienne): Moulin Pochas

The faluns of Amberre are located south of the basin of the Loire in the Midwest of France in the department of Vienne in region Nouvelle-Aquitaine. These fossiliferous levels from *la mer des faluns* (Chevalier & Charlot, 1858) were deposited in a shallow environment, Middle Miocene. The south of this basin is delimited by a coast formed by digitized marine advances. The westernmost one forms the Gulf of Mirebeau in which are deposited the faluns of Moulin Pochas [also called Moulin Pochard (Gillard, 1936; Lecointre, 1947; Cariou & Joubert, 1989)]. The early authors geologists of the Ligerian Basin (Desnoyer, 1829; Dujardin, 1837) very early discovered a different age and more recent than the deposits of the Paris Basin. During the nineteenth and twentieth centuries, many authors subdivided the different levels encountered (cf. Lecointre, 1947). Depéret (1895) clarifies his vision of the stratigraphy and defines the Vin-

dobonian [Langhian-Tortonian] stage by grouping the Helvetian and the Tortonian, which he considers to be facies. Then more recent deposits were dissociated from the previous ones, scattered in a more restricted basin called Redonian (Dollfus, 1900) [Messinian-Gelasian]. This floor was much discussed during the 20<sup>th</sup> century, notably by Brébion (1964) and by Lauriat-Rage (1981). The faluns of Moulin Pochas (commune of Amberre) have been known since the nineteenth century (Longue-mar, 1870). These faluns are located and visible in an old quarry [x = 433, 1375; Y = 2197.3375; Z = 115] formerly used for the manufacture of building materials or for soil improvement, now conserved in Geosite. We found at Moulin Pochas two different Neogene transgressive levels. The most known Miocene deposit, the oldest, is constituted by marine deposits characteristic of the coastal zones, these faluns deposited in the middle Miocene on a Mesozoic substratum. Then another falun deposited in Messinian epoch (?) (pers. com. D. Nereaudeau 2017). Recently, several phases have been recognized in Redonian spreading from the end of the Tortonian to the Gelasian [Nereaudeau et al., 2003; Van Dingenen et al., 2015]. In the 1980s, one of us (J-F Lesport) collected in a part of the quarry a marine stenohaline fauna of small molluscs and bryozoans attributed hypothetically to the late Miocene. Among this community with a malacofauna more than 200 species, polyplacophora valves were discovered in a soft and

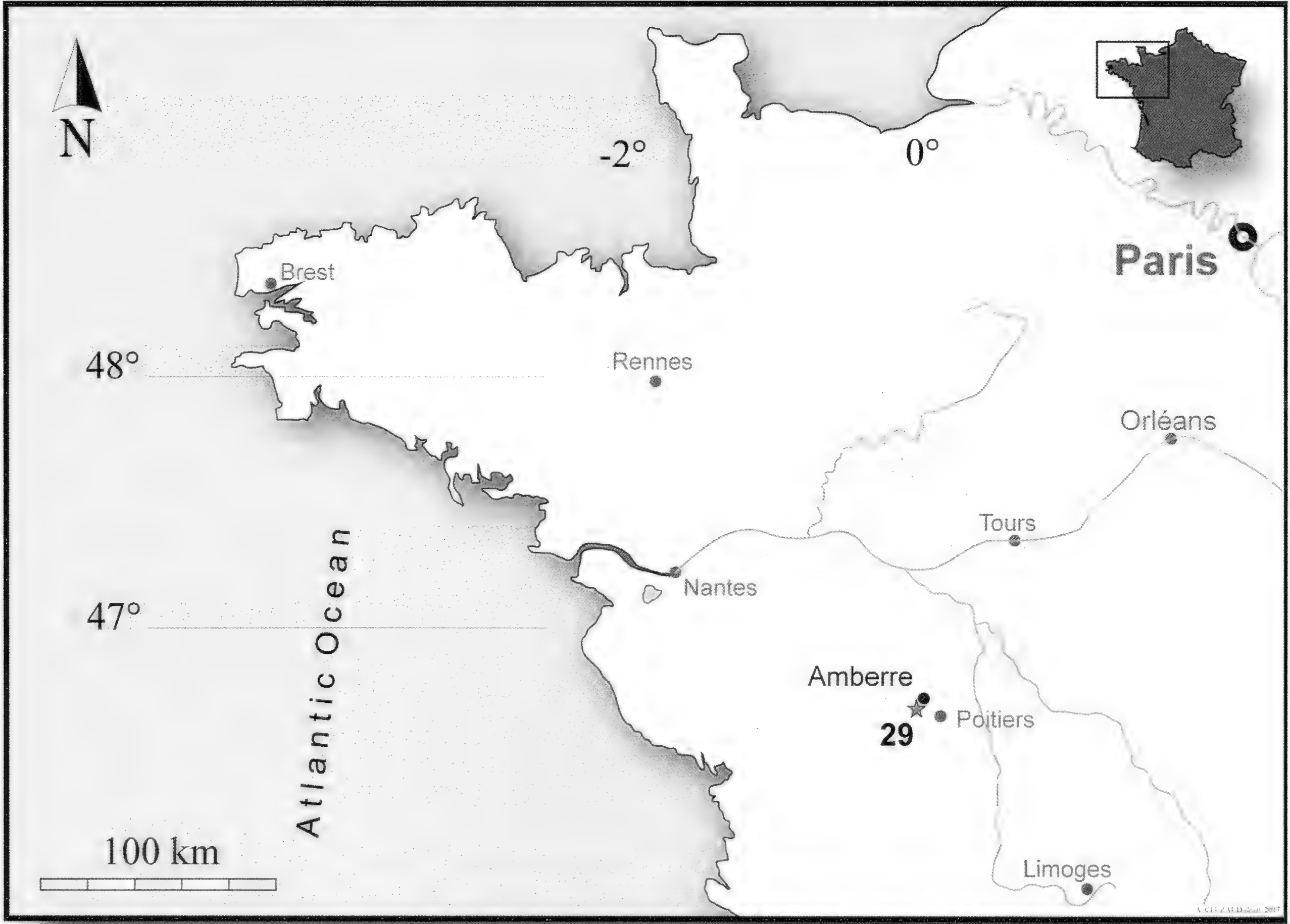


Fig. 1B. Study area and site location of the Ligerian Basin (29: Moulin Pochas).

Fig. 1B. Area di studio e ubicazione dei siti del bacino Ligeriano.



reddish falun in a matrix of fine sand. The fragility of the tests, particularly those of reticulate bryozoan colonies, perfectly conserved, testifies to a calm sea in the bottom of a gulf.

## Previous records of chitons from the Aquitaine and Ligerian Basins

The paleontological documentation of Polyplacophora (“chitons”) from the Aquitaine basin is quite scant; very few records were provided by Rolle (1862), Benoist (1881), de Rochebrune (1882) and Cossmann & Peyrot (1917). We consider the work of de Rochebrune dated in 1882 (and not 1883 as usually reported) because the volume was published in different parts (two *cahiers*). The first *cahier* is dated August 1882, annotated at the bottom of the cover of the first fascicle. This first part contains the text and the three plates of de Rochebrune work.

Rolle (1862) described three species from the Oligocene of Gaas: *Chiton oligocaenus*, *Chiton reussi* and *Chiton modestus*, of which syntypes are preserved at NHMW (Kroh & Dell’Angelo, in study). Benoist (1881) in a short list of the species sent to de Rochebrune to determine, added three species from Gaas (*Tonicia gaasensis*, *Tonicia waltebledi* and *Lepidopleurus daubrei*) and reported two other species from the Miocene: *Acanthochites dulignonii* (from Largileyre) and *Callochiton benoisti* (from Mérignac). De Rochebrune (1882) reported the same eight species (he considered *Chiton reussi* as a synonym of *Chiton oligocaenus*) and Cossmann & Peyrot considered two other species, *Chiton miocenicus* (from the Miocene of Salies-de-Béarn and Largileyre) and *Chiton leognanensis* from the Miocene of Léognan.

A few specimens of the type material in the collections of MHNbX could not be found. Almost all specimens from Benoist’s collection were recovered, with the exception of the unique specimen of *Acanthochites dulignonii* Rochebrune, 1882. The tube with its label containing this species was found empty. Thus the holotype may be lost.

Another type specimen was not found, no tube or label exists in the MHNbX for *Chiton leognanensis* Cossmann & Peyrot, 1917. This species comes from Bial de Bellerade’s collection. We found in the basement of the Robin Museum of Libourne (Gironde, France), stored in boxes, part of the collection of Charles Paul Bial de Bellerade (1845-1918), a renowned entomologist but also a malacologist of the Aquitaine’s fossils. It would appear that the mollusc collection is not there. The collection of insects had been offered at the University of Bordeaux where it is still located, it is possible that the collection of fossil molluscs is also at the University of Bordeaux 1, but not currently located or recognised.

Other informations has been given more recently (e.g. Vergneau, 1966; Dell’Angelo & Palazzi 1989; Varone, 2008; Cahuzac et al., 2012). The species reported in these papers are discussed herein and in the second part of the work for the remaining families.

Another paper on Eocene to Oligocene chitons from the Paris and Hampshire Basins has been recently published (Cherns & Schwabe, 2017), and despite the wrong references to the Paris Basin in the title, some species from the sites of Gaas (Aquitaine Basin!) and Abbesse are described. The latter locality “Abbesse, Bourgogne, France” is also wrongly referenced, the correct name is Abbesse (or Abesse) in Aquitaine area (Saint-Paul-lès-Dax, Landes), not in Bourgogne (center of France). No information is known, at our knowledge, regarding the chiton fauna of the Ligerian Basin.

## Systematics

We follow the family-level classification proposed by Sirenko (2006), except for the genus *Lucilina*, which we consider distinct from *Tonicia* following Schwabe et al. (2008, p. 24). Since many of the chiton species were already exhaustively described from other Mediterranean Neogene sites (e.g. Laghi, 1977; Dell’Angelo et al., 1999, 2004, 2012, 2013, 2015, 2016; Garilli et al., 2005), only short synonymy related to fossil taxa, some comments and stratigraphic ranges are given below. The geographic range and habitat of species extending to the Recent were described by Dell’Angelo & Smriglio (1999).

Class Polyplacophora Gray, 1821  
Subclass Loricata Schumacher, 1817  
Order Lepidopleurida Thiele, 1909  
Family Leptochitonidae Dall, 1889  
Genus *Lepidopleurus* Risso, 1826

## Type species

*Chiton cajetanus* Poli, 1791, by subsequent designation (Herrmannsen, 1846). Non: *Lepidopleurus* (Carpenter MS) Dall, 1879 (= *Lepidozona* Pilsbry, 1892).

## Remarks

Three species attributed with certainty to the genus *Lepidopleurus* are present in Europe: *L. cajetanus* (Poli, 1791) from the Miocene to present-day, *L. benoisti* (de Rochebrune, 1882) from the Miocene, and *L. virgifer* (Sandberger, 1859) from the Oligocene of Germany, while the generic attribution to *Lepidopleurus* or *Leptochiton* for other species (Eocene - Oligocene) from France, Germany and Ukraine is more uncertain.

## Distribution

The genus is known from the Eocene to the Recent of Europe.

*Lepidopleurus cajetanus* (Poli, 1791)  
(Figs 2A-I)

1791 *Chiton cajetanus* Poli, p. 10, pl. 4, figs 1-2.  
Additions to the bibliography in Dell’Angelo et al. (2015: 220):



2015 *Lepidopleurus cajetanus* (Poli) - Dell'Angelo et al., p. 220, pl. 1, figs 1-12.

## Type material

Lectotype designated by Dell'Angelo & Palazzi (1989), lost specimen figured by Poli (1791: pl. 4, fig. 1).

## Type locality

Gaeta (Latina, Italy), Tyrrhenian Sea (41°12'53"N, 13°34'35"E).

## Material examined

**Burdigalian:** Léognan (Le Thil Kiosque 2): 1 tail valve (PR).

**Langhian:** Manciet (Pouyouet): 1 tail valve (PR).

**Late Miocene:** Amberre (Moulin-Pochas): 20 valves (2 head, 16 intermediate and 2 tail) (PR).

Maximum width: 5 / 7.8 / 5.4 mm.

## Remarks

The species is characterized by a tegmentum sculptured with strong, concentric, terraced ribs on the head valve, lateral areas of intermediate valves and postmucronal area of the tail valve. Additionally there are branching or anastomosing longitudinal chains of granules in the central area of intermediate valves and antemucronal area of the tail valve. Detailed descriptions of this species are in Dell'Angelo & Smriglio (1999) and Dulai (2005).

The valves of *Lepidopleurus cajetanus* show an high degree of variability, mainly in the sculpture of the tegmentum (Dell'Angelo et al., 2015) and in the shape of intermediate valves (Dell'Angelo et al., 2013). Also tail valves of juvenile specimens show remarkable variations. For example, the mucro is almost central in juvenile specimens but moves posterior (even to the end of the valve) as individuals grew older, due to the bulging of the posterior area on the ventral side (Laghi, 1977; Dulai, 2005; Dell'Angelo et al., 2013, 2015).

The material examined is quite homogeneous, without variation in sculpture, consisting of regular longitudinal chains of granules, generally inclined towards the side margins. There is scarce evidence of the branching and anastomosing chains that are so frequent in valves

from the Miocene (Tortonian) of N. Italy (e.g. Dell'Angelo et al., 2015, pl. 1, figs 4-12).

These new records for the species extend the stratigraphic range of *L. cajetanus* earlier in the Miocene to the Burdigalian.

## Distribution

**Early Miocene:** northeastern Atlantic (Burdigalian): Aquitaine Basin, France (this paper); **Middle Miocene:** northeastern Atlantic (Langhian): Aquitaine Basin, France (this paper); Paratethys Langhian-Serravallian): Austria, Czech Republic, Poland, Romania, Hungary, Ukraine (Dulai, 2005; Dell'Angelo et al., 2007; Studenka & Dulai, 2010); **Late Miocene:** northeastern Atlantic: Ligerian Basin, France (this paper); Proto-Mediterranean Sea (Tortonian and Messinian): Po Basin, N. Italy (Laghi, 1977; Dell'Angelo et al., 1999, 2015). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al., 2004); central Mediterranean, Italy (Laghi, 1977; Dell'Angelo et al., 2001, 2013). **Pleistocene:** central Mediterranean, Italy (Sabelli & Taviani, 1979), Greece and Cyprus (Garilli et al., 2005; Koskeridou et al., 2009). **Recent:** Atlantic Ocean, from Spain and Portugal south to Morocco and Canary Islands; Mediterranean (Dell'Angelo & Smriglio, 1999).

## *Lepidopleurus benoisti* (de Rochebrune, 1882) (Figs 2J-U, 3A-F)

1824 *Chiton cinereus* f. Poli - Bonelli, n° 2648 (fide Sacco, 1897, non *Chiton cinereus* Linnaeus, 1767).

1842 *Chiton Cinereus* Linn. - Sismonda, p. 24 (fide Sacco, 1897, non *Chiton cinereus* Linnaeus, 1767).

1847 *Chiton Cajetanus* Poli - Sismonda, p. 25 (fide Sacco, 1897, non *Chiton cajetanus* Poli, 1791).

1852 *Chiton miocenicus* Michelotti - d'Orbigny, p. 94 (fide Dell'Angelo & Palazzi, 1989) non *Chiton miocenicus* Michelotti, 1847).

1852 *Chiton subcajetanus* d'Orbigny, p. 94, n° 1746 (fide Dell'Angelo & Palazzi, 1989) *Nomen nudum*.

1882 *Gymnoplax benoisti* de Rochebrune, p. 64, pl. 1, fig. 8.

1882 *Callochiton benoisti* Rochebrune - Benoist, p. xxix.

1882 *Gymnoplax orbignyi* de Rochebrune, p. 65, pl. 1, fig. 7.

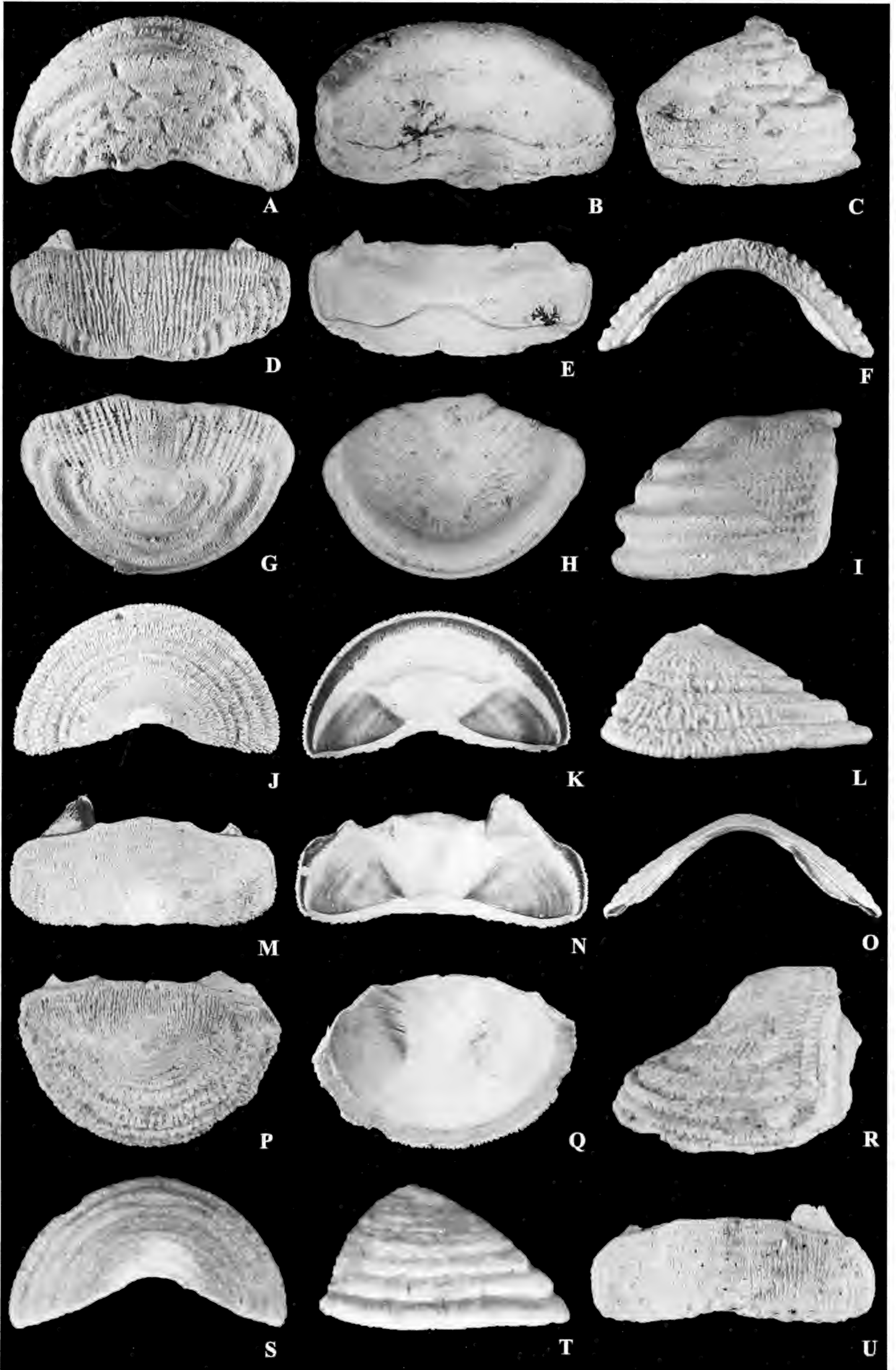
1882 *Chiton subcajetanus* Poli - de Rochebrune, p. 65 (in synonymy of *Gymnoplax orbignyi*)

1882 ? *Chiton Cinereus* Lin. - de Rochebrune, p. 70 (non *Chiton cinereus* Linnaeus, 1767).

**Fig. 2. A-I.** *Lepidopleurus cajetanus* (Poli, 1791), Amberre (Moulin-Pochas), France, Ligerian Basin, Miocene (Messinian?). **A-C.** Head valve, width 5 mm, dorsal, ventral and lateral views (PR). **D-F.** Intermediate valve, width 7.5 mm, dorsal, ventral and frontal views (PR). **G-I.** Tail valve, width 5.4 mm, dorsal, ventral and lateral views (PR). **J-U.** *Lepidopleurus benoisti* (de Rochebrune, 1882). **J-R.** Saint-Paul-lès-Dax (Abesse RG), France, Aquitaine Basin, Oligocene (Chattian) (AC). **J-L.** Head valve, width 15.5 mm, dorsal, ventral and lateral views. **M-O.** Intermediate valve, width 18 mm, dorsal, ventral and frontal views. **P-R.** Tail valve, width 15.5 mm, dorsal, ventral and lateral views. **S-T.** Pessac (Lorient), France, Aquitaine Basin, Miocene (Burdigalian), head valve, width 9.8 mm, dorsal and lateral views (JFL). **U.** Bazas (La Flotte), France, Aquitaine Basin, Miocene (Burdigalian), intermediate valve, width 12.4 mm, dorsal view (AC).

**Fig. 2. A-I.** *Lepidopleurus cajetanus* (Poli, 1791), Amberre (Moulin-Pochas), Francia, Bacino Ligeriano, Miocene (Messiniano?). **A-C.** Piastra anteriore, larghezza 5 mm, viste dorsale, ventrale e laterale (PR). **D-F.** Piastra intermedia, larghezza 7,5 mm, viste dorsale, ventrale e frontale (PR). **G-I.** Piastra posteriore, larghezza 5,4 mm, viste dorsale, ventrale e laterale (PR). **J-U.** *Lepidopleurus benoisti* (de Rochebrune, 1882). **J-R.** Saint-Paul-lès-Dax (Abesse RG), Francia, Bacino Aquitaniano, Oligocene (Chattiano) (AC). **J-L.** Piastra anteriore, larghezza 15,5 mm, viste dorsale, ventrale e laterale. **M-O.** Piastra intermedia, larghezza 18 mm, viste dorsale, ventrale e frontale. **P-R.** Piastra posteriore, larghezza 15,5 mm, viste dorsale, ventrale e laterale. **S-T.** Pessac (Lorient), Francia, Bacino Aquitaniano, Miocene (Burdigaliano), piastra anteriore, larghezza 9,8 mm, viste dorsale e laterale (JFL). **U.** Bazas (La Flotte), Francia, Bacino Aquitaniano, Miocene (Burdigaliano), piastra intermedia, larghezza 12,4 mm, vista dorsale (AC).







- 1895 *Chiton benoisti* (de Roch.) - Degrange-Touzin, p. 407.  
 1897 *Middendorffia subcajetana* (D'Orb.) - Sacco, p. 90, pl. 7, figs 21-25.  
 1917 *Chiton miocaenicus* Michelotti - Cossmann & Peyrot, p. 32, pl. 2, figs 21-22 (*fide* Dell'Angelo & Palazzi, 1989, *non Chiton miocenicus* Michelotti, 1847).  
 1917 *Chiton Benoisti* (de Rochebrune) - Cossmann & Peyrot, p. 33, pl. 2, figs 23-27.  
 1934 *Lepidopleurus* (*Lepidopleurus*) *decoratus* Reuss - Šulc, p. 3 (*partim*).  
 1977 *Lepidopleurus subcajetanus* (d'Orbigny) - Laghi, p. 99, pl. 1, fig. 21  
 1981 *Gymnoplax benoisti* de Rochebrune - Van Belle, p. 23 (gen. inquir.).  
 1981 *Gymnoplax orbignyi* de Rochebrune - Van Belle, p. 55 [in synonymy of *Lepidopleurus decoratus* Reuss].  
 1981 *Chiton subcajetanus* Poli - Van Belle, p. 74 [in synonymy of *Lepidopleurus decoratus* Reuss].  
 1984 *Middendorffia subcajetana* Sacco - Ferrero Mortara et al., p. 299, pl. 55, fig. 6.  
 1984 *Lepidopleurus subcajetanus* d'Orbigny - Bałuk, p. 285.  
 2000 *Lepidopleurus subcajetanus* (Orb.) - Bielikryś, p. 165.  
 ? 2003 *Lepidopleurus subcajetanus* Sacco - Kroh, p. 132, pl. 2, fig. 1.  
 2005 *Lepidopleurus subcajetanus* d'Orbigny - Dulai, p. 31 (in synonymy of *L. cajetanus*).  
 2010 *Lepidopleurus subcajetanus* d'Orbigny - Studencka & Dulai, p. 263, fig. 3E (in synonymy of *L. cajetanus*).  
 2015 *Lepidopleurus benoisti* (de Rochebrune) - Dell'Angelo et al., p. 222, pl. 2, figs 1-13, 18-20.

## Type material

Syntypes MHNbX 2014.14.20.0, two tail valves from Benoit's collection (widths 13.63 and 7.04 mm).

## Type locality

Mérignac (*Mytilus* level, *fide* Benoist, 1882), Gironde (France).

## Type stage

Early Miocene, Aquitanian/Burdigalian.

## Material examined

**Chattian, Late Oligocene:** Saint-Paul-lès-Dax (Estoti): 5 tail valves (AC); Saint-Paul-lès-Dax (Abesse RG): 10 valves (4 head, 1 intermediate, 5 tail), (AC, JVC).

**Aquitanian:** Saint-Paul-lès-Dax (Mañot): 1 tail valve (PR).

**Burdigalian:** Meilhan (Carrière Vives 1): 2 tail valves (AC, JFL); Meilhan (Carrière Vives 3): 1 intermediate valve (AC); Meilhan (Carrière Vives 9): 1 tail valve (PR); Meilhan: 1 tail valve (BD); Léognan (Le Thil 3): 1 intermediate valve (PR); Léognan (Le Thil 2): 22 valves (3 head, 10 intermediate and 9 tail) (JFL, PR); Lucbardez (Cantine de Bargues): 1 tail valve (PR); Pessac (Lorient): 7 valves (1 head, 6 tail) (AC, JFL, PR); Saint-Paul-lès-Dax (Cabanes): 1 tail valve (JFL); Noaillan (Cachac): 3 tail valves (AC, JFL); Bazas (La Flotte): 1 intermediate valve (AC); Saucats (Peloua): 33 valves (1 intermediate and 32 tail) (AC, JFL, JVC, PR); Saint-Martin-de-Hinx (Bordepouy): 1 head valve (AC).

**Langhian:** Le Houga (Carrière): 1 tail valve (JFL).

**Serravallian:** Orthez (Le Paren): 1 tail valve (BD).

Maximum width: 15.7 / 18 / 18 mm.

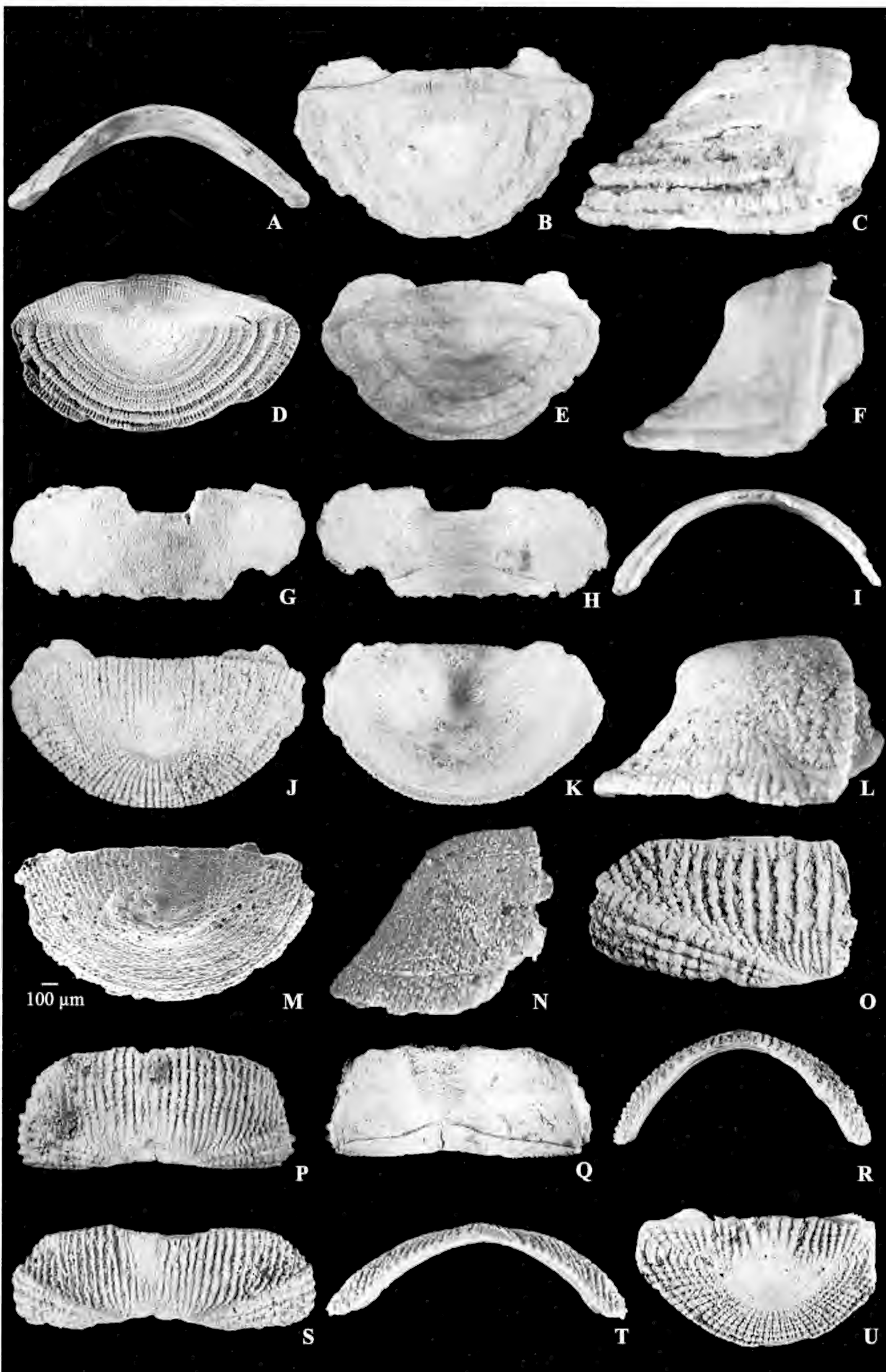
## Description (based on syntypes at MHNbX and new material)

Head valve large, semicircular, posterior margin widely V-shaped, slope almost straight or slightly convex, interrupted by the profile of the concentric, terraced ribs. Intermediate valves wide, broadly rectangular, rounded, moderately elevated (height/width = 0.33-0.36), anterior and posterior margins straight, side margins rounded, apex inconspicuous, lateral areas not very raised. Tail valve semicircular, elevated, width a little less than two times the length ( $L/W = 0.55-0.60$ ), mucro flat, in anterior position, anterior slope almost straight or slightly convex, posterior slope slightly concave. Sculpture of head valve, lateral areas of intermediate valves and postmucronal area of tail valve formed by 3-4 (up to 5-6 in lateral areas of intermediate valves) concentric, terraced ribs, intersected by numerous and

**Fig. 3. A-F.** *Lepidopleurus benoisti* (de Rochebrune, 1882). **A.** Bazas (La Flotte), France, Aquitaine Basin, Miocene (Burdigalian), intermediate valve, width 12.4 mm, frontal view (AC). **B-C.** Saucats (Peloua), France, Aquitaine Basin, Miocene (Burdigalian), tail valve, width 14.5 mm, dorsal and lateral views (JFL). **D.** Orthez (Le Paren), France, Aquitaine Basin, Miocene (Serravallian), tail valve, width 8 mm, dorsal view (BD). **E-F.** Le Houga (Carrière Gélis), France, Aquitaine Basin, Miocene (Langhian), tail valve, width 4.2 mm, dorsal and lateral views (JFL). **G-L.** *Lepidopleurus poirieri* (de Rochebrune, 1882), Gaas (Lagouarde), France, Aquitaine Basin, Oligocene (Rupelian) (AC). **G-I.** Intermediate valve, width 2.7 mm, dorsal, ventral and frontal views. **J-L.** Tail valve, width 2.8 mm, dorsal, ventral and lateral views (DA). **M-N.** *Leptochiton* cf. *L. josei* Dell'Angelo, Sosso, Prudenza & Bonfitto, 2013, Noaillan (Gamachot), tail valve, width 1.9 mm, dorsal and lateral views (BD). **O-U.** *Leptochiton aturriensis* n. sp. **O-T.** Pontonx-sur-l'Adour (Mineur), France, Aquitaine Basin, Oligocene (Chattian). **O.** Half left intermediate valve, width 8.2 mm, dorsal view (AC). **P-R.** Holotype MHNbX 2017.7.1, intermediate valve (ex AC), width 12 mm, dorsal, ventral and frontal views. **S-T.** Intermediate valve, width 12 mm, dorsal and frontal views (AC). **U.** Saint-Paul-lès-Dax (Abesse RG), tail valve, width 7 mm, dorsal view (AC).

**Fig. 3. A-F.** *Lepidopleurus benoisti* (de Rochebrune, 1882). **A.** Bazas (La Flotte), Francia, Bacino Aquitaniano, Miocene (Burdigaliano), piastra intermedia, larghezza 12,4 mm, vista frontale (AC). **B-C.** Saucats (Peloua), Francia, Bacino Aquitaniano, Miocene (Burdigaliano), piastra posteriore, larghezza 14,5 mm, viste dorsale e laterale (JFL). **D.** Orthez (Le Paren), Francia, Bacino Aquitaniano, Miocene (Serravalliano), piastra posteriore, larghezza 8 mm, vista dorsale (BD). **E-F.** Le Houga (Carrière Gélis), Francia, Bacino Aquitaniano, Miocene (Langhiano), piastra posteriore, larghezza 4,2 mm, viste dorsale e laterale (JFL). **G-L.** *Lepidopleurus poirieri* (de Rochebrune, 1882), Gaas (Lagouarde), Francia, Bacino Aquitaniano, Oligocene (Rupeliano) (AC). **G-I.** Piastra intermedia, larghezza 2,7 mm, viste dorsale, ventrale e frontale. **J-L.** Piastra posteriore, larghezza 2,8 mm, viste dorsale, ventrale e laterale (DA). **M-N.** *Leptochiton* cf. *L. josei* Dell'Angelo, Sosso, Prudenza & Bonfitto, 2013, Noaillan (Gamachot), piastra posteriore, larghezza 1,9 mm, viste dorsale e laterale (BD). **O-U.** *Leptochiton aturriensis* n. sp. **O-T.** Pontonx-sur-l'Adour (Mineur), Francia, Bacino Aquitaniano, Oligocene (Chattiano). **O.** Mezza piastra intermedia sinistra, larghezza 8,2 mm, vista dorsale (AC). **P-R.** Olotipo, MHNbX 2017.7.1, piastra intermedia (ex AC), larghezza 12 mm, viste dorsale, ventrale e frontale. **S-T.** Piastra intermedia, larghezza 12 mm, viste dorsale e frontale (AC). **U.** Saint-Paul-lès-Dax (Abesse RG), piastra posteriore, larghezza 7 mm, vista dorsale (AC).







very irregular branching or anastomosing radial chains of granules. In central area of intermediate valves and antemucronal area of tail valve the concentric ribs are inconspicuous, barely visible (and not terraced), and the sculpture is formed by many longitudinal chains of granules, almost regular in the central part, much less regular and tending to branching and anastomosing in the lateral parts, near the side margins.

Articulamentum without insertion laminae, apophyses narrow, rounded-triangular, widely projected in intermediate valves, larger but not completely preserved in tail valves.

## Remarks

An in-depth study of *Chiton subcajetanus* d'Orbigny, 1852 *sensu* Sacco, 1897 and the related species (*Gymnoplax orbignyi* de Rochebrune, 1882 and *G. benoisti* de Rochebrune, 1882) was made by Dell'Angelo et al. (2015), and they considered this species a *nomen nudum* (no diagnosis, *nec* figuration in d'Orbigny, Sismonda and Bonelli). The valid species name (including for the large valves of *L. decoratus* of Šulc) is *Lepidopleurus benoisti* (de Rochebrune, 1882). This species was previously known only from the intermediate and tail valves described by de Rochebrune (1882) from Mérignac, by Cossmann & Peyrot (1917) from this and other French Miocene localities (Léognan and Saucats), and by Sacco (1897) for the tail valves from the Torino hill. No head valve was known, and the descriptions were scant, so we re-describe this species here.

The valves found mainly include tail valves (69 of a total of 93), and it is possible to see a certain range of variability. In juvenile specimens the mucro is more pronounced and the posterior slope decidedly concave (Fig. 3F, width 4.2 mm), while the mucro remains in the anterior position in fully developed specimens (Fig. 3C, width 14.5 mm), contrary to what happens for *Lepidopleurus cajetanus*.

The report of *Chiton miocenicus* Michelotti, 1847 by Cossmann & Peyrot (1917: 32, pl. 2, figs 21-22) can be attributed to *Lepidopleurus benoisti*, as already indicated by Dell'Angelo & Palazzi (1989: 55). Cossmann & Peyrot found three tail valves from Salies-de-Béarn (coll. Degrange-Touzin), one of which figured in pl. 2, figs 21-22; we examined these valves preserved at MHNbX and can confirm the attribution to *L. benoisti*.

These new records for the species extend the stratigraphic distribution of *L. benoisti* to the late Oligocene.

## Comparisons

A similar species is *Lepidopleurus virgifer* (Sandberger, 1859) from the middle Oligocene (Rupelian) of Waldböckelheim (Germany), whose type material (Syntypes) are present at NHMW (Kroh & Dell'Angelo, in study). The shape and the ornamentation of the valves are similar, but the sculpture is more coarser in *L. benoisti*, with more pronounced growth lines, and the size of the valves is greater (Dell'Angelo et al., 2015, and unpub-

lished data). Also the geographic and stratigraphic range of the species is different, from late Oligocene (Chattian) of France to early and middle Miocene of France, North Italy and Paratethys for *L. benoisti*, vs. middle Oligocene of Germany for *L. virgifer*, and this is consistent to consider *L. virgifer* and *L. benoisti* as distinct species.

## Distribution

**Late Oligocene:** northeastern Atlantic (Chattian): Aquitaine Basin, France (this paper). **Early Miocene:** northeastern Atlantic (Aquitainian-Burdigalian): Aquitaine Basin, France (Cossmann & Peyrot, 1917; this paper); Proto-Mediterranean Sea (Burdigalian): N. Italy, Torino Hill (Sacco, 1897; Dell'Angelo et al., 2015); **Middle Miocene:** northeastern Atlantic (Langhian): Aquitaine Basin, France (this paper); Paratethys (Langhian-Serravallian): Austria, Ukraine (Šulc, 1934; Studencka & Dulai, 2010).

Genus *Leptochiton* Gray, 1847

## Type species

*Chiton cinereus* Montagu, 1803, non Linnaeus, 1767 (= *Chiton asellus* Gmelin, 1791), by subsequent designation (Gray, 1847).

## Remarks

The taxonomic relationship between the two genera *Lepidopleurus* Risso, 1826 and *Leptochiton* Gray, 1847 has been at length debated, with different points of view (Pilsbry, 1892; Ferreira, 1979; Dell'Angelo & Palazzi, 1989, 1991), and also a recent molecular phylogenetic study of the order Lepidopleurida has not completely resolved the problem (Sigwart et al., 2011). We consider in this work *Lepidopleurus* ("valves solid, tegmentum heavily sculptured of heavy concentric ridges") and *Leptochiton* ("valves thin, tegmentum finely granulose, granules of equal size") to be distinct genera (Kaas & Van Belle, 1985).

## Distribution

This genus occurs worldwide (Kaas & Van Belle 1985a). Numerous species are known living along the northeastern Atlantic frontage and Mediterranean Sea. *Leptochiton* is one of the most ancient genera, dating back to the Triassic [*L. davolii* (Laghi, 2005) from the Triassic of Italy] and possibly even to the early Carboniferous (Sirenko 2013).

*Leptochiton poirieri* (de Rochebrune, 1882)  
(Figs 3G-L)

1882 *Lepidopleurus poirieri* de Rochebrune, p. 56, pl. 1, fig. 10.  
1892 *Chiton Poirieri* de Roch. - Cossmann, p. 332, pl. 9, figs 1-2.  
1941 *Chiton* spec. - Görges, p. 151, pl. 7, fig. 7 (*fide* Janssen, 1978).



- 1978 *Lepidopleurus poirieri* Rochebrune - Janssen, p. 221, pl. 15, figs 20-27.  
 1981 *Leptochiton poirieri* (De Rochebrune) - Van Belle, p. 57.  
 1986 *Lepidopleurus poirieri* Rochebrune - Hocht, p. 209.  
 1989 *Lepidopleurus* (*Leptochiton*) *poirieri* de Rochebrune - Dell'Angelo & Palazzi, p. 68, pls 18-19.  
 1995 *Lepidopleurus poirieri* Rochebrune - Gürs, p. 23, pl. 1, figs 5-7.  
 2009 *Lepidopleurus* cf. *poirieri* Rochebrune - Welle, p. 84, pl. 1, fig. 1.  
 2011 *Leptochiton poirieri* (de Rochebrune) - Dell'Angelo et al., p. 953.  
 2011 *Lepidopleurus* aff. *poirieri* Rochebrune - Müller, p. 21, pl. 4, figs 1-6.  
 2017 *Leptochiton* cf. *algesirensis* (Capellini) - Cherns & Schwabe, p. 1, Fig. 1 [*non Leptochiton algesirensis* (Capellini, 1859)].

## Type material

Lectotype, designated by Janssen, 1978, tail valve figured by de Rochebrune (1882, pl. 1, fig. 10b).

## Type locality

Jeurre, near Étampes, Essonne (France).

## Type stage

Oligocene (Rupelian).

## Material examined

**Oligocene, Rupelian:** Gaas (Espibos): 8 tail valves (DA, PR); Gaas (Lagouarde): 3 valves (1 intermediate and 2 tail) (AC, DA). Maximum width: -- / 2.7 / 3.8 mm.

## Remarks

The species is characterized by the rounded intermediate valves, and the tegmentum sculpture with dense granules arranged in radial series on the head valve, lateral areas of intermediate valves and postmucronal area of tail valve, in longitudinal series in central area of intermediate valves and antemucronal area of tail valve. Detailed descriptions of this species are in Janssen (1978) and Dell'Angelo & Palazzi (1989).

This species was described on material from localities of French Oligocene, Jeurre and Étréchy (de Rochebrune, 1882; Cossmann, 1892) and was confirmed by Janssen (1978) for the French middle Oligocene (Auvers-Saint-Georges) and also for the German middle to late Oligocene (middle: Waldböckelheim/ Gienberg, Waldböckelheim/ Welschberg, Weinheim/ Zeilstück; late: Glimmerode, Freden, Söllingen, Doberg, Rumeln).

The figure of the tail valve of Bezancon collection (de Rochebrune, 1882, pl. 1, fig. 10b) designated by Janssen as lectotype (the same tail valve also figured by Cossmann, 1892: pl. 9, fig. 2) is insufficient to identify the species with certainty. The attribution to *Leptochiton poirieri* of the examined material from Gaas is based mainly on the description and figures of Janssen (1978), who was able to compare French and German Oligocene material,

and on the comparison with some valves from German Oligocene (provided by Janssen to one of the authors).

## Comparisons

Many *Leptochiton* species have a similar tegmental sculpture with granules arranged in radial and longitudinal series, two of them [*L. maguntiacus* (de Rochebrune, 1882), considered a synonym of *L. algesirensis* (Capellini, 1859) by Dell'Angelo & Palazzi, 1859, and *L. chaticus* (Janssen, 1978)] are known from the Oligocene of Germany, the others still extant in Mediterranean Sea or Atlantic Ocean, and/or with a stratigraphic distribution that does not extend deeper than the Miocene.

*Leptochiton maguntiacus* is a very similar species, with a coarser sculpture (more regular, fine and with a fairly pronounced parallelism of the series of granules in *L. poirieri*) and a lower number of radial striae of granules in lateral areas of intermediate valves.

*Leptochiton chaticus* differs from *L. poirieri* by the different shape of tail valve (more elliptical, less raised and with the mucro in a more anterior position), and the lower number of radial striae of granules in lateral areas of intermediate valves (13 for *L. chaticus* vs. 20-22 for *L. poirieri*).

## Distribution

**Early-middle Oligocene:** North Sea Basin, Germany (Müller, 2011), northeastern Atlantic (Rupelian): Paris Basin, Aquitaine Basin, France (Janssen, 1978; Cherns & Schwabe, 2017; this paper); (Rupelian): North Sea Basin, Germany (Janssen, 1978; Hocht, 1986; Gürs, 1995; Welle, 2009); **Late Oligocene:** North Sea/Tethys (early Chattian): Mainz Basin, Germany (Janssen, 1978).

*Leptochiton* cf. *L. josei* Dell'Angelo, Sosso, Prudenza & Bonfitto, 2013  
(Figs 3M-N)

2013 *Leptochiton josei* Dell'Angelo, Sosso, Prudenza & Bonfitto, p. 73, pl. 2, figs M-R.

## Type material

Holotype: MZB 49985 (an intermediate valve). Paratypes: MZB 49984 (a tail valve), MSNG 56535 (an intermediate valve), and private collections.

## Type locality

Genova, Sestri Ponente, Italy (44°25'33"N, 08°50'53"E).

## Type stage

Early Pliocene (Zanclean).

## Material examined

**Burdigalian:** Noaillan (Gamachot): 1 tail valve, width 1.8 mm (BD).



## Remarks

The unique valve available, a small fragile tail valve, is characterized by the semi-elliptical shape, and the sculpture of tegmentum formed by rather irregular, roundish separated granules, arranged in longitudinal series in the antemucronal area and in radial series in the postmucronal one, crossed by growth lines.

It is similar to *Leptochiton josei* Dell'Angelo, Sosso, Prudenza & Bonfitto, 2013, known from the Pliocene of Liguria (N. Italy), from which it differs by the higher tail valve, the mucro located in a more anterior position, and the almost straight postmucronal slope. These differences and the rarity of the studied material (a unique tail valve) led us to the tentative identification.

This new record for the species tentatively extends the stratigraphic distribution of *L. josei* to the early Miocene.

## Distribution

**Early Miocene:** northeastern Atlantic (Burdigalian): Aquitaine Basin, France (this paper). **Pliocene:** central Mediterranean, Italy (Dell'Angelo et al., 2013).

*Leptochiton aturriensis* n. sp.  
(Figs 3O-U, 4A-C)

## Type material

Holotype: MHNbX 2017.7.1, an intermediate valve (ex AC), width 12 mm (Figs 3P-R). Paratype: MHNbX 2017.7.2, a tail valve (ex AC), width 9.4 mm (Figs 4A-C).

## Type locality

Pontonx-sur-l'Adour (Mineur), Landes (France).

## Type stage

Oligocene, Chattian.

## Etymology

From the first name of the river Adour (in Latin "Aturrus" and in Euskara (Basque language) "Aturri", the first spelling or the oldest known) and of geologic sub-basin (Adour basin). The Basque people have lived in the southwest of France and North-northwest of Spain since well before the Celtic invasions.

## Other material

**Chattian, late Oligocene:** Pontonx-sur-l'Adour (Mineur): 12 valves (11 intermediate and 1 tail) (AC); Saint-Paul-lès-Dax (Estoti): 3 intermediate valves (AC); Saint-Paul-lès-Dax (Abesse RG): 5 valves (1 intermediate and 4 tail) (AC, DA). Maximum width: -- / 14 / 9.4 mm.

## Description

Head valve not known.

Intermediate valves wide, rounded, elevated (height/width = 0.47), anterior and posterior margins straight, side margins rounded, apex inconspicuous, lateral areas raised.

Tail valve semielliptical, elevated, width ca. two times the length (L/W = 0.48), anterior margin straight, mucro flat, in anterior position, anterior slope slightly convex, posterior slope a little concave directly behind the mucro.

Sculpture of central area of intermediate valves and antemucronal area of tail valve formed by longitudinal chains of large and irregular granules, ca. 33 in the Holotype, tending to branching and anastomosing in the posterior margin near the apex. In lateral areas of intermediate valves and in the postmucronal area of tail valve the sculpture is formed by radial chains of granules, 4-5 in the lateral areas of the holotype (4-6 in additional specimens), tending to split near the side margins, without evidence of growth lines, and ca. 40 in the postmucronal area of Paratype 1.

Articulamentum without insertion laminae, apophyses not completely preserved in the studied material.

## Remarks

The shape and sculpture of the studied valves are well characterized and show a low variability. Only an intermediate valve from Pontonx-sur-l'Adour, width 12 mm, is flatter, less rounded, almost subcarinated, height/width = 0.31 (Figs 3S-T).

## Comparisons

*Leptochiton aturriensis* n. sp. differs from *Lepidopleurus benoisti* by the higher intermediate valves (height/width 0.47 vs. 0.32-0.36), and the more regular and less coarse sculpture, with no evidence of terraced ribs in lateral areas of intermediate valves and postmucronal area of tail valve.

Many species of *Lepidopleurus/Leptochiton* have been described from the Oligocene of Germany: *Lepidopleurus virgifer* (Sandberger, 1859), *Leptochiton maguntiacus* (de Rochebrune, 1882), *Leptochiton uhligi* (Koenen, 1892), *Leptochiton chatticus* Janssen, 1978, *Leptochiton eckelsheimensis* Gürs, 1992, and *Leptochiton paeninsulae* Gürs, 1992, while *Leptochiton poirieri* (de Rochebrune, 1882) was described from the Oligocene of the Paris basin (around Etampes, France) and is also known from the Oligocene of Germany (Janssen, 1978) and the Aquitaine Basin (see above).

*Lepidopleurus virgifer* differs from *L. aturriensis* n. sp. by the very irregular and coarse sculpture, particularly in the lateral areas of intermediate valves and postmucronal area of tail valve, sculptured with numerous diverging, coarsely granulated radial ribs, crossed by coarse growth ridges.

*Leptochiton poirieri*, *L. maguntiacus* and *L. chatticus* differ from *L. aturriensis* n. sp. by the finer and regular sculpture with a different number both of longitudinal and radial striae of granules (e.g. 20-22 on the lateral areas



of intermediate valves for *L. poirieri*, 16-20 for *L. maguntiacus*, 13 for *L. chatticus*, vs. 4-6 for *L. aturriensis* n. sp.). *Leptochiton uhligi* is a different species with a very fine sculpture, looking at first glance almost smooth. *Leptochiton eckelsheimensis* and *L. paeninsulae* are species with a different sculpture, smooth to slightly grainy in central area of intermediate valves and antemucronal area of tail valve, and with coarse pustules irregularly distributed and forming outer radial rows in lateral area of intermediate valves and postmucronal area of tail valve.

## Distribution

**Late Oligocene:** northeastern Atlantic (Chattian): Aquitaine Basin, France (this paper).

Genus *Parachiton* Thiele, 1909

## Type species

*Lepidopleurus* (*Parachiton*) *acuminatus* Thiele, 1909 by original designation.

## Remarks

*Parachiton* was originally established by Thiele (1909) as a subgenus of *Lepidopleurus* on the basis of its disproportionately large tail valve with subterminal mucro, and overall similarities of the other valves with species of *Lepidopleurus*. It is now considered to be a distinct genus (Sirenko, 2006), also due to differences in the radula (Saito, 1996). To date there are 23 Recent species known, all from the Indo-West Pacific except for *P. africanus* (Nierstrasz, 1906) from the Mediterranean Sea.

## Distribution

The genus is known from the Miocene to the Recent. Two species attributed with certainty to the genus *Parachiton* are known from the Miocene-Pleistocene deposits in the Mediterranean area [*P. statianus* Dell'Angelo, Giuntelli, Sosso & Zunino, 2015 from the Miocene (Tortonian) of N. Italy, and *P. africanus* from the Pliocene-Pleistocene of Italy] and the Miocene (Badenian) of Paratethys [*P. thielei* Šulc, 1934, a synonym of *P. africanus*].

*Parachiton statianus* Dell'Angelo, Giuntelli, Sosso & Zunino, 2015  
(Figs 4D-F)

2004 *Lepidopleurus* (*Parachiton*) aff. *africanus* Nierstraz - Dell'Angelo et al., p. 29, pl. 2, figs 2, 6 [fide Dell'Angelo et al., 2015, non *Parachiton africanus* (Nierstrasz, 1906)].  
2015 *Parachiton statianus* Dell'Angelo, Giuntelli, Sosso & Zunino, p. 230, pl. 4, figs 1-9.

## Type material

Holotype: MGPT PU 108784 (a tail valve). Paratypes, all

from the type locality: MGPT PU 108785 (an intermediate valve); NHMW 2014/0450/0001-0002 (an intermediate and a tail valves); BD 122-123 (an intermediate and a tail valves).

## Type locality

Rio di Bocca d'Asino (Alessandria), Piedmont, Italy.

## Type stage

Late Miocene, Tortonian.

## Material examined

**Messinian ?:** Amberre (Moulin-Pochas): 1 intermediate valve, width 6 mm (PR).

## Remarks

The species is characterized by the tegmentum finely granulose, with granules fairly smoothly coalescing and arranged in ca. 90-95 longitudinal rows on central area of intermediates valves and antemucronal area of tail valve, and in more than 100 fine radiating rows on the postmucronal area of tail valve. It was recently described by Dell'Angelo et al. (2015) from the Miocene (Tortonian) of Rio di Bocca d'Asino (N. Italy). Here we extend its stratigraphic distribution to the late Miocene of the Ligerian Basin.

## Comparisons

The differences with *Parachiton africanus* (Nierstrasz, 1906) are discussed in Dell'Angelo et al. (2015, pp. 230-231).  
For the differences with *Parachiton palmorum* n. sp. see below.

## Distribution

**Late Miocene:** northeastern Atlantic: Ligerian Basin, France (this paper); Proto-Mediterranean Sea (Tortonian): Po Basin, N Italy (Dell'Angelo et al., 2015). **Pliocene:** western Mediterranean, Estepona Basin, Spain: Velerin Antena (Dell'Angelo et al., 2004).

*Parachiton palmorum* n. sp.  
(Figs 4G-L)

## Type material

Holotype: MHNbX 2017.9.1, a tail valve (ex BD), width 3.2 mm (Figs 4G-J). Paratype: MZB 32134, a tail valve (ex BD), width 3 mm (Figs 4K-L).

## Type locality

Vives quarry, Meilhan, Landes (France).



## Type stage

Miocene, Burdigalian.

## Etymology

The name honours Birgitte and Eivind Palm (Højer, Denmark), who collected and donated the type material.

## Description of the holotype

Tail valve wider than long (L/W estimated ca. 0.58), width 3.2 mm, depressed, rounded mucro located at about 2/10th of the length of the valve towards the posterior margin, antemucronal slope straight or slightly convex, postmucronal slope straight, but for a little excavation directly behind the mucro.

Tegmentum sculptured with oval fine granules arranged in 50 enough regular longitudinal series on the antemucronal area, on the sides diverging anteriorly; postmucronal area with the roundish granules arranged in ca. 70 radial series, crossed by two concentric growth lines.

Articulamentum weakly developed, apophyses small, not completely preserved.

## Remarks

In spite of the scarcity and incompleteness of the material, the characters are well defined, and suitable for the description of the species as new. We did not find any head and intermediate valves of this species. The tail valve characteristics are diagnostic for *Parachiton*.

## Comparisons

This species at a first look resembles *Parachiton africanus* (Nierstrasz, 1906), from which differs by the shape of the tail valve (much more wider than long in *P. palmorum* n. sp., L/W estimated ca. 0.58 vs. 0.72-0.81 in *P. africanus*), the position of the mucro (located more posteriorly in *P. africanus*), and the sculpture of the longitudinal rows of granules, well evidenced and not coalescing in *P. palmorum* n. sp., fairly smoothly coalescing in *P.*

*africanus*. *Parachiton africanus* is a rare Mediterranean species, described based on a single specimen from Oran, Algeria, whose holotype is in the RMNH, no. 2783, deprived of its end valves (Kaas, 1977), and known as a fossil from the Mediterranean Pliocene-Pleistocene deposits (Dell'Angelo & Palazzi, 1989; Dell'Angelo & Smriglio, 1999) and from the middle Miocene (Badenian) of Paratethys (Austria and Poland), as *P. thielei* Šulc, 1934 (Šulc, 1934; Bařuk, 1984; Dell'Angelo et al., 2015).

*Parachiton palmorum* n. sp. differs from *P. stianus* by the position of the mucro (located more posteriorly in *P. stianus*), the sculpture of the longitudinal rows of granules (well evidenced and not coalescing in *P. palmorum* n. sp., fairly smoothly coalescing in *P. stianus*), and the number of longitudinal (50 vs. 90-95) and radial (70 vs. > 100) rows of granules.

## Distribution

**Early Miocene:** northeastern Atlantic (Burdigalian): Aquitaine Basin, France (this paper).

Family Hanleyidae Bergenhayn, 1955

Genus *Hanleya* Gray, 1857

## Type species

*Hanleya debilis* Gray, 1857 (= *Chiton hanleyi* Bean in Thorpe, 1844), by monotypy.

## Remarks

The genus *Hanleya* in Atlantic Ocean and in Mediterranean Sea has been recently revised by Sirenko (2014) and Sirenko et al. (2016), that defined two new species from Atlantic (*H. harasewyschi* Sirenko, 2014) and Mediterranean (*H. mediterranea* Sirenko, 2014) and considered *H. nagelfar* (Lovén, 1846) as a junior synonym of *H. hanleyi*.

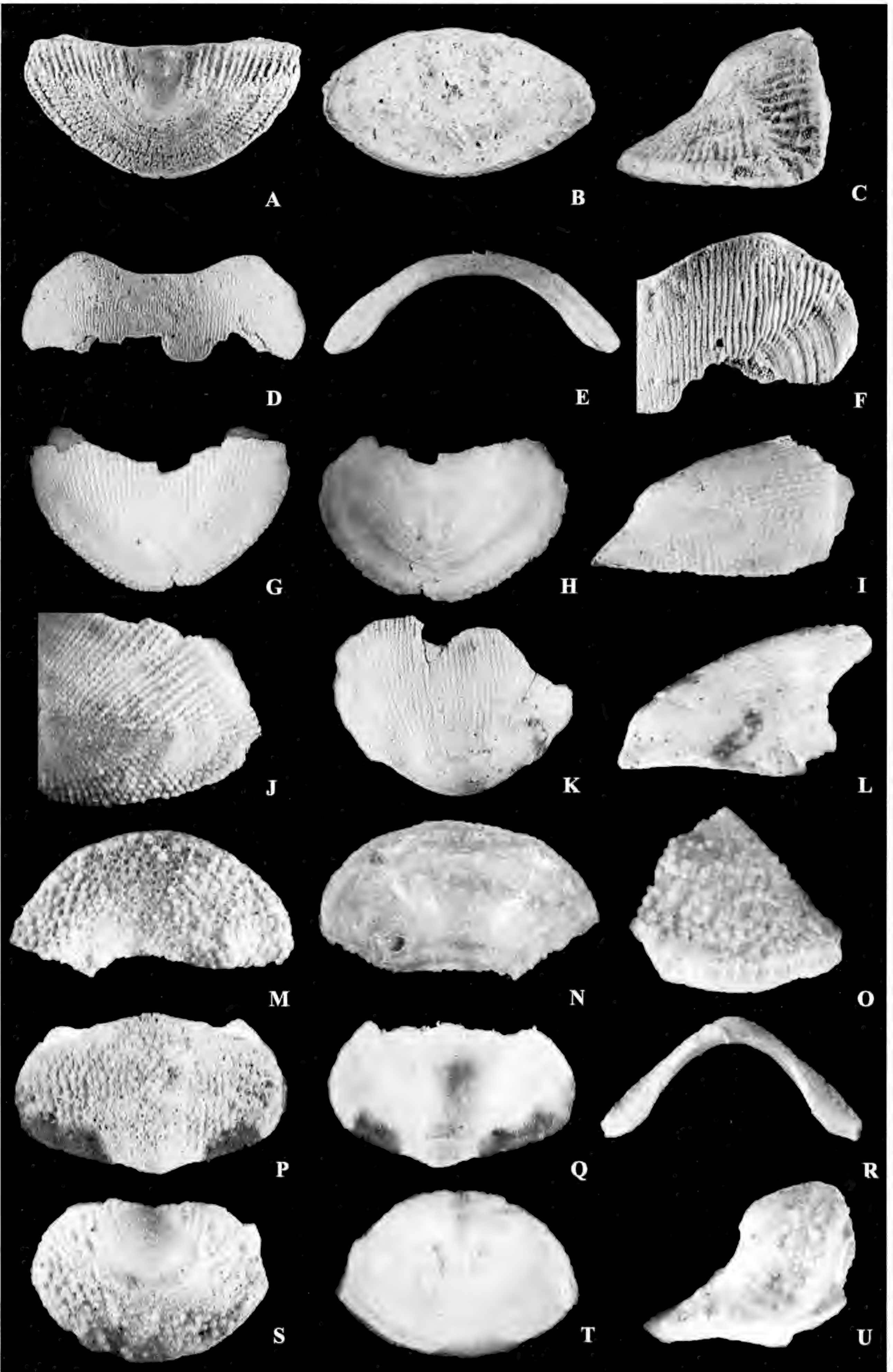
## Distribution

The genus is known from the Oligocene to Recent. Four species of *Hanleya* are known from the European Ceno-

**Fig. 4. A-C.** *Leptochiton aturriensis* n. sp., Pontonx-sur-l'Adour (Mineur), France, Aquitaine Basin, Oligocene (Chattian), Paratype, MHNbX 2017.7.2, tail valve (ex AC), width 9.4 mm, dorsal, ventral and lateral views. **D-F.** *Parachiton stianus* Dell'Angelo, Giuntelli, Sosso & Zunino, 2015, Amberre (Moulin-Pochas), France, Ligerian Basin, Miocene (Messinian?), intermediate valve, width 6 mm (PR). **D-E.** Dorsal and frontal views. **F.** Detail of the sculpture of right half valve. **G-L.** *Parachiton palmorum* n. sp., Meilhan, France, Aquitaine Basin, Miocene (Burdigalian). **G-J.** Holotype, MHNbX 2017.9.1, tail valve (ex BD), width 3.2 mm. **G-I.** Dorsal, ventral and lateral views. **J.** Detail of the sculpture. **K-L.** Paratype, MZB 32134, tail valve (ex BD), width 3 mm, dorsal and lateral views. **M-U.** *Hanleya glimmerodensis* Janssen, 1978, Gaas, France, Aquitaine Basin, Oligocene (Rupelian) (DA). **M-O.** Gaas (Lagouarde), head valve, width 2.2 mm, dorsal, ventral and lateral views. **P-R.** Gaas (Espibos), intermediate valve, width 2.7 mm, dorsal, ventral and frontal views. **S-U.** Gaas (Espibos), tail valve, width 3.3 mm, dorsal, ventral and lateral views.

**Fig. 4. A-C.** *Leptochiton aturriensis* n. sp., Pontonx-sur-l'Adour (Mineur), Francia, Bacino Aquitaniano, Oligocene (Chattiano), Paratipo, MHNbX 2017.7.2, piastra posteriore (ex AC), larghezza 9,4 mm, viste dorsale, ventrale e laterale. **D-F.** *Parachiton stianus* Dell'Angelo, Giuntelli, Sosso & Zunino, 2015, Amberre (Moulin-Pochas), Francia, Bacino Ligeriano, Miocene (Messiniano?), piastra intermedia, larghezza 6 mm (PR). **D-E.** Viste dorsale e frontale. **F.** Dettaglio della scultura della mezza piastra sinistra. **G-L.** *Parachiton palmorum* n. sp., Meilhan, Francia, Bacino Aquitaniano, Miocene (Burdigaliano). **G-J.** Olotipo, MHNbX 2017.9.1, piastra posteriore (ex BD), larghezza 3,2 mm. **G-I.** Viste dorsale, ventrale e laterale. **J.** Dettaglio della scultura. **K-L.** Paratipo, MZB 32134, Piastra posteriore (ex BD), larghezza 3 mm, viste dorsale e laterale. **M-U.** *Hanleya glimmerodensis* Janssen, 1978, Gaas, Francia, Bacino Aquitaniano, Oligocene (Rupeliano) (DA). **M-O.** Gaas (Lagouarde), piastra anteriore, larghezza 2,2 mm, viste dorsale, ventrale e laterale. **P-R.** Gaas (Espibos), piastra intermedia, larghezza 2,7 mm, viste dorsale, ventrale e frontale. **S-U.** Gaas (Espibos), piastra posteriore, larghezza 3,3 mm, viste dorsale, ventrale e laterale.







zoic, *H. hanleyi* (Bean in Thorpe, 1844) and *H. mediterranea* Sirenko, 2014 from the Mediterranean Sea and the Late Miocene of North Italy, *H. multigranosa* (Reuss, 1860) from the Paratethys, and *H. glimmerodensis* Janssen, 1978 from the Oligocene of Germany.

***Hanleya glimmerodensis* Janssen, 1978  
(Figs 4M-U)**

1978 *Hanleya glimmerodensis* Janssen, p. 222, pl. 15, figs 28-30.  
1981 *Hanleya glimmerodensis* Janssen - Van Belle, p. 41.  
1995 *Hanleya glimmerodensis* Janssen - Gürs, p. 25.  
2011 *Hanleya glimmerodensis* Janssen - Dell'Angelo et al., p. 953.  
2014 *Hanleya glimmerodensis* Janssen - Sirenko, p. 18.

### Type material

Holotype SMF 250038, a tail valve figured by Janssen, 1978 (pl. 15, fig. 30). Paratypes SMF, an head (SMF 250040) and an intermediate valve (SMF 250039), figured by Janssen, 1978 (pl. 15, figs 28-29).

### Type locality

Tagebau Höllkopf near Glimmerode, Germany.

### Type stage

Oligocene (early Chattian), Kasseler Meeressand.

### Material examined

**Oligocene, Rupelian:** Gaas (Espibos): 6 valves (1 head, width 1.8 mm, 2 intermediate, maximum width 2.7 mm, and 3 tail, maximum width 3.3 mm) (DA); Gaas (Lagouarde): 1 head valve, width 2.2 mm (DA).

### Remarks

The species is characterized by a tegmental sculpture consisting of well marked longitudinal rows of granules on pleural areas of intermediate valves and antemucronal area of tail valve, and of irregularly distributed granules on the head valve, lateral areas of intermediate valves and postmucronal area of tail valve. Detailed description was provided by Janssen (1978).

The material examined is not well preserved, the valves are somewhat eroded and the sculpture is not always clearly visible, but the attribution to *Hanleya glimmerodensis* is consistent. We found only some differences in the sculpture of tegmentum, also present in the jugal area in our material, more insubstantial or less defined in the jugal area in the valves described and figured by Janssen. The species, previously known only from the Late Oligocene of Germany, is reported for the first time from the Aquitaine Basin.

### Comparisons

This species is similar to *Hanleya hanleyi*, with which it

shares the same type of tegmental sculpture, and from which it differs by slight differences in the valves shape and by the different geographic and stratigraphic range, from extant Mediterranean Sea and Atlantic Ocean up to Late Miocene of North Italy for *H. hanleyi*.

*Hanleya mediterranea* Sirenko, 2014 differs from *H. glimmerodensis* by the different tegmental sculpture, characterized by the lacking of longitudinal rows of granules across the entire central area of intermediate valves and antemucronal area of tail valve, and by the presence of large granules comprising two or more small granules in pleural areas.

### Distribution

**Middle Oligocene:** northeastern Atlantic (Rupelian): Aquitaine Basin, France (this paper); **Late Oligocene:** North Sea/Tethys (early Chattian): Mainz Basin, Germany (Janssen, 1978).

Order Chitonida Thiele, 1909

Suborder Chitonina Thiele, 1909

Superfamily Chitonoidea Rafinesque, 1815

Family Ischnochitonidae Dall, 1889

Genus *Ischnochiton* Gray, 1847

### Type species

*Chiton textilis* Gray, 1828, by subsequent designation (Gray, 1847: 168).

### Remarks

The diagnoses of subgenera within *Ischnochiton* are based mainly on girdle characters, so it is preferable to not use subgenera for fossil species.

### Distribution

The genus is known from the Eocene to the Recent.

***Ischnochiton rissoi* (Payraudeau, 1826)  
(Figs 5A-I)**

1826 *Chiton rissoi* Payraudeau, p. 87, pl. 3, figs 4-5.

Additions to the bibliography in Dell'Angelo et al. (2015: 232):  
2015 *Ischnochiton rissoi* (Payraudeau) - Dell'Angelo et al., p. 232, pl. 4, figs 15-17.

### Type material

Syntype at MNHN 6109.

### Type locality

Bonifacio, Corse, France (41°23'10"N, 9°09'31"E).

### Material examined

**Burdigalian:** Meilhan (Carrière Vives 1): 1 head valve



(JFL); Meilhan (Carrière Vives 9): 2 tail valves (JFL, PR); Meilhan: 9 valves (6 intermediate and 3 tail) (BD); Martillac (coupe du fossé près de la Solitude): 2 valves (1 head and 1 intermediate) (JFL); Noaillan (Gamachot): 66 valves (10 head, 40 intermediate and 16 tail) (AC, BD, JFL, PR); Pouydesseaux (Maureilhan): 8 valves (3 head, 4 intermediate and 1 tail) (BD); Saint-Jean-de-Marsacq (Lahitet): 1 intermediate valve (PR).

**Serravallian:** Sallespisse (Carré): 1 head valve (DA).

Maximum width: 4.2 / 6.2 / 6 mm.

## Remarks

The species is characterized by a tegmental sculpture consisting of concentric vermicular ribs, often intersected by fine radial furrows, on the head valve, lateral areas of intermediate valves and postmucronal area of the tail valve. The ribs continue longitudinally on the central area of intermediate valves and on the antemucronal area of the tail valve, more spaced near the lateral margins, thinner and closer together in the jugal area. The species is highly variable, with a complicated synonymy (Nierstrasz, 1906), and detailed descriptions are in Kaas & Van Belle (1990) and Dell'Angelo & Smriglio (1999).

The valves examined show a high degree of variability, both in shape and sculpture. The profile of intermediate valves is rounded, some valves higher than extant *I. rissoi* (Fig. 5F, compare with Dell'Angelo & Smriglio, 1999, pl. 29, fig. D), the height/width ratio in the measured intermediate valves ranges between 0.40 and 0.48. Also the shape of tail valve is variable, from antemucronal and postmucronal slopes almost straight, almost to set in a row, to antemucronal slope slightly convex and postmucronal slope slightly concave, as extant *I. rissoi* (e.g. Dell'Angelo & Smriglio, 1999, pl. 29, fig. H).

Most of the intermediate valves examined (and similarly for the tail ones) presents the sculpture formed by longitudinal vermicular ribs on the central area rather obsolete, more defined towards the lateral margins and weaker in the middle part, so as to give the impression of not being present on the jugal area. But on few valves the sculpture of the jugal area is visible, so that we can confirm which is present on the entire central area, as can be seen from the intermediate valve figured (Fig. 5D).

These new records for the species extend the stratigraphic distribution of *Ischnochiton rissoi* to the early Miocene (Burdigalian).

## Comparisons

*Ischnochiton rissoi* shows some resemblance to *Stenoplax paviai* Dell'Angelo, Giuntelli, Sosso & Zunino, 2014, from which it differs by the shape of tail valve, less elongate ( $L/W = 0.56$  vs.  $0.61-0.69$  in *S. paviai*), the sculpture of the tegmentum (concentric grooves and longitudinal grooves less numerous, more coarse and spaced in *S. paviai*), and the number of slits in each side of intermediate valves (1 in *I. rissoi* vs. 2 in *S. paviai*).

## Distribution

**Early Miocene:** northeastern Atlantic (Burdigalian): Aquitaine Basin, France (this paper); **Middle Miocene:** northeastern Atlantic (Serravallian): Aquitaine Basin, France (this paper); Paratethys (Langhian-Serravallian): Austria, Czech Republic, Hungary, Poland, Romania, Ukraine (Dulai, 2005; Studencka & Dulai, 2010); **Late Miocene:** Proto-Mediterranean Sea (Tortonian and Messinian): Po Basin, N Italy (Laghi, 1977; Dell'Angelo et al., 1999, 2015). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al., 2004); central Mediterranean, Italy (Dell'Angelo et al., 2013). **Pleistocene:** central Mediterranean, Italy, Greece (Garilli et al., 2005). **Recent:** Mediterranean Sea (Dell'Angelo & Smriglio, 1999); Atlantic coasts of Spain (Carmona Zalvide & García, 1999, 2000).

### *Ischnochiton korytnicensis* Bałuk, 1971 (Figs 5J-L)

1971 *Ischnochiton korytnicensis* Bałuk, p. 458, pl. 3, figs 1-4.

Additions to the bibliography in Dell'Angelo et al. (2015: 234):

2015 *Ischnochiton korytnicensis* Bałuk - Dell'Angelo et al., p. 234, pl. 5, figs 1-9.

## Type material

Holotype in Bałuk's collection, reg. No. BkK-A15, an intermediate valve illustrated in Bałuk (1971: pl. 3, fig. 2).

## Type locality

Korytnica, 24 km SSW of Kielce ( $50^{\circ}39'49''N$ ,  $20^{\circ}31'41''E$ ), southern slopes of the Holy Cross Mts. (Poland).

## Type stage

Middle Miocene, Langhian/Serravalian (Badenian).

## Material examined

**Burdigalian:** Meilhan (Carrière Vives 9): 2 valves (1 intermediate, width 5 mm, and 1 tail, width 5.2 mm) (JFL); Meilhan: 1 tail valve, width 4.3 mm (BD).

## Remarks

The species is characterized by a tegmental sculpture consisting of closely spaced, elevated, irregularly shaped nodules on the head valve, the lateral areas of the intermediate valves and the postmucronal area of the the tail valve, and longitudinal, clearly undulating ribs on the central area of the intermediate valves and the antemucronal area of the tail valve. Bałuk (1971) provided a detailed description of *I. korytnicensis*.

These new records for the species extend the stratigraphic distribution of *Ischnochiton korytnicensis* to the early Miocene (early Burdigalian).



## Distribution

**Early Miocene:** northeastern Atlantic (Burdigalian): Aquitaine Basin, France (this paper); **Middle Miocene:** Paratethys (Langhian-Serravallian): Poland (Bałuk, 1984; Macioszczyk, 1988); **Late Miocene:** Proto-Mediterranean Sea (Tortonian and Messinian) (Laghi, 1977; Dell'Angelo et al., 1999, 2015). **Pliocene:** central Mediterranean, Italy: Liguria (Dell'Angelo et al., 2013).

*Ischnochiton renardi* n. sp.  
(Figs 5M-R)

## Type material

Holotype: MHNbX 2017.8.1, an intermediate valve (ex PR), width 6.4 mm (Figs 5M-O). Paratypes: MZB 32135, an intermediate valve (ex PR), width 5.4 mm; MHNbX 2017.8.2, an intermediate valve (ex PR), width 7.5 mm (Figs 5P-R).

## Type locality

Amberre (Moulin-Pochas), Ligerian Basin, France.

## Type stage

Messinian? late Miocene.

## Other material

Late Miocene: Amberre (Moulin-Pochas): 4 intermediate valves, maximum width 7 mm (PR).

## Etymology

The name honours Philippe Renard (Beauzelle, France), who collected and donated the type material.

## Description

Head and tail valves not known.

Intermediate valves rectangular, carinated, moderately elevated (height/width = 0.4 in the holotype), posterior

margin almost straight, side margins rounded, apex inconspicuous, lateral areas slightly raised.

Sculpture formed by granulose riblets, ca. 52-56 longitudinal in the central area (56 in the Holotype), and 6-7 radial in the lateral areas, tending to split near the side margins, with evidence of growth lines. The longitudinal riblets tending to be more irregular towards the side margins, with scarce evidence of interstices, and cover also the jugal area. The radial granulose riblets in the lateral areas are larger than the longitudinal ones in the central area, and the granules tending to coalesce near the anterior margin.

Articulamentum with apophyses wide, scarcely preserved in our material, one slit for each side.

## Remarks

Despite the studied material consists only of intermediate valve in not good state of preservation, the features are such as to allow the description as a new species.

## Comparison

The main characters like the sculpture formed by granulose riblets and the carinated shape are different from the other three *Ischnochiton* species known from the Miocene deposits, *I. rissoi*, *I. korytnicensis* and *I. ligusticus* Dell'Angelo, Sosso, Prudenza & Bonfitto, 2013.

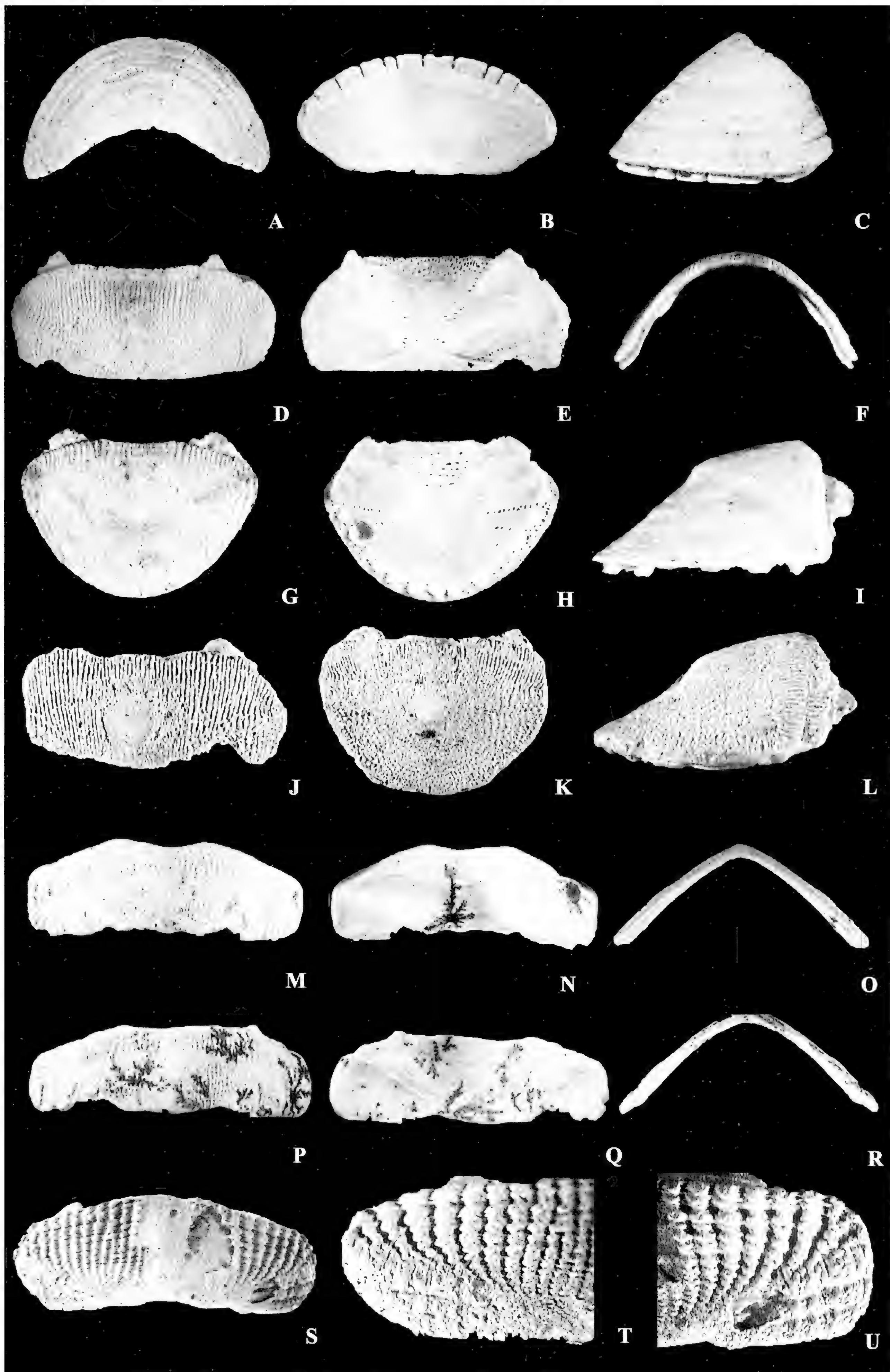
*Ischnochiton renardi* n. sp. differs from *I. rissoi* by the tegmental sculpture and the shape of the intermediate valves (rounded in *I. rissoi*). *Ischnochiton korytnicensis* differs from *I. renardi* n. sp. in the type of ornamentation, with closely spaced nodular elevations that are irregular in outline and irregularly distributed (see above). Also the tegmental sculpture of *I. ligusticus*, with irregular granules arranged in segments of various size and shape, slightly overlapping each other, forming rugosities, is different from that of the new species here described.

This species at a first look resembles *Ischnochiton zbyi* Dell'Angelo & Silva, 2003 from the Pliocene of Vale de Freixo, Mondego Basin, Portugal, from which differs by the different sculpture, longitudinal sulci with interstices almost equal or slightly narrower than sulci and

**Fig. 5. A-I.** *Ischnochiton rissoi* (Payraudeau, 1826), France, Aquitaine Basin, Miocene (Burdigalian). **A-C.** Meilhan (Carrière Vives 1), head valve, width 7.5 mm, dorsal, ventral and lateral views (JFL). **D-F.** Pouydesseaux (Maureilhan), intermediate valve, width 5 mm, dorsal, ventral and frontal views (BD). **G-I.** Noaillan (Gamachot), tail valve, width 3 mm, dorsal, ventral and lateral views (BD). **J-L.** *Ischnochiton korytnicensis* Baluk, 1971, Meilhan (Carrière Vives 9), France, Aquitaine Basin, Miocene (Burdigalian) (JFL). **J.** Intermediate valve, width 5 mm, dorsal view. **K-L.** Tail valve, width 5.2 mm, dorsal and lateral views. **M-R.** *Ischnochiton renardi* n. sp., Amberre (Moulin-Pochas), France, Ligerian Basin, Miocene (Messinian?). **M-O.** Holotype, MHNbX 2017.8.1, intermediate valve (ex PR), width 6.4 mm, dorsal, ventral and lateral views. **P-R.** Paratype 2, MHNbX 2017.8.2, intermediate valve (ex PR), width 7.5 mm, dorsal, ventral and lateral views. **S-U.** *Ischnochiton abbessi* Cherns & Schwabe, 2017, Noaillan (Gamachot), France, Aquitaine Basin, Miocene (Burdigalian), MHNbX 2017.9.2, intermediate valve (ex BD), width 7.8 mm. **S.** Dorsal view. **T-U.** Dorsal views of half left and right valves.

**Fig. 5. A-I.** *Ischnochiton rissoi* (Payraudeau, 1826), Francia, Bacino Aquitaniano, Miocene (Burdigaliano). **A-C.** Meilhan (Carrière Vives 1), piastra anteriore, larghezza 7,5 mm, viste dorsale, ventrale e laterale (JFL). **D-F.** Pouydesseaux (Maureilhan), piastra intermedia, larghezza 5 mm, viste dorsale, ventrale e frontale (BD). **G-I.** Noaillan (Gamachot), piastra posteriore, larghezza 3 mm, viste dorsale, ventrale e laterale (BD). **J-L.** *Ischnochiton korytnicensis* Baluk, 1971, Meilhan (Carrière Vives 9), Francia, Bacino Aquitaniano, Miocene (Burdigaliano) (JFL). **J.** Piastra intermedia, larghezza 5 mm, vista dorsale. **K-L.** Piastra posteriore, larghezza 5,2 mm, viste dorsale e laterale. **M-R.** *Ischnochiton renardi* n. sp., Amberre (Moulin-Pochas), Francia, Bacino Ligeriano, Miocene (Messiniano?). **M-O.** Olotipo, MHNbX 2017.8.1, piastra intermedia (ex PR), larghezza 6,4 mm, viste dorsale, ventrale e laterale. **P-R.** Paratype 2, MHNbX 2017.8.2, piastra intermedia (ex PR), larghezza 7,5 mm, viste dorsale, ventrale e laterale. **S-U.** *Ischnochiton abbessi* Cherns & Schwabe, 2017, Noaillan (Gamachot), Francia, Bacino Aquitaniano, Miocene (Burdigaliano), MHNbX 2017.9.2, piastra intermedia (ex BD), larghezza 7,8 mm. **S.** Vista dorsale. **T-U.** Viste dorsali di mezza piastra sinistra e destra.







smooth jugum in *I. zbyi* (Dell'Angelo & Silva, 2003: figs 5-6), granulose riblets with scarce evidence of interstices, and covering also the jugal area in *I. renardi* n. sp. Moreover the different geographic and stratigraphic range, late Miocene of Ligerian Basin (France) for *Ischnochiton renardi* n. sp., vs. Pliocene of Mondego Basin (Portugal) for *I. zbyi*.

## Distribution

**Late Miocene:** northeastern Atlantic: Ligerian Basin, France (this paper).

*Ischnochiton abbessi*  
(Cherns & Schwabe, 2017) n. comb.  
(Figs 5S-U, 6A-C)

2017 *Chaetopleura abbessi* Cherns & Schwabe, p. 8, figs 6J-N.

## Type material

Holotype, an intermediate valve (ZSM Mol 20071427).

## Type locality

Abbesse, Aquitaine, France.

Rectification: ICZN - 76A.2. - A statement of a type locality that is found to be erroneous should be corrected. Cherns & Schwabe (2017) give Abbesse situated in Bourgogne as locality type. Bourgogne may refer to a French administrative region, to former provinces, to various places and to derived appellations. The current name of the French administrative region is Bourgogne-Franche-Comté and is located in the center-east of France. No chattian marine deposits (late Oligocene) are known from this area. Some chattian outcrops exist around Dijon (Côte-d'Or), all known for its land and lacustral deposits (e.g. Courville, 2011).

The Faluns of Abesse – a name given by the 19th century authors – to belong to a fossiliferous zone exposed at different outcrops situated in the sector of the *forges* (smitheries) of Abesse (also spelled Abbesse) located in the municipality of Saint-Paul-lès Dax, Landes department, SW France (see

Lesport *et al.*, 2015 for more information).

The type locality Abbesse is not in Bourgogne-Franche-Comté, center-east France but in Aquitaine southwestern France (Collector confirmation D. Fehse, pers. com. 11/2017).

## Type stage

Upper Oligocene, Chattian.

## Material examined

**Burdigalian:** Noaillan (Gamachot), France: 1 intermediate valve (ex BD), MHNbX 2017.9.2, width 7.8 mm (Figs 5S-U, 6A-C).

## Remarks

The characters of the unique intermediate valve from the Burdigalian of Noaillan (Gamachot) agree with those reported by Cherns & Schwabe (2017) in the description of *Chaetopleura abbessi* from the late Oligocene of Abbesse (or Abesse), also based on the finding of a unique intermediate valve. We found some slight differences in the shape of the examined intermediate valve ( $W/L = 2.74$  vs.  $3.6$  for the valve described by Cherns & Schwabe, and  $H/W = 0.34$  vs.  $0.30$ ), but the studied material is really scarce, and does not allow to define the intraspecific variability of this species.

The generic assignment of this species is changed from *Chaetopleura* to *Ischnochiton* herein, based on the following considerations. The family Chaetopleuridae is differentiated from Ischnochitonidae by “tegmenum generally sculptured with pustules, apophyses very wide, almost connected across jugal sinus” vs. “tegmenum generally sculptured with grooves and nodulose ribs, apophyses neatly separated” (Kaas & Van Belle, 1985b: 7-8). The apophyses of both the valves from Abbesse and Noaillan (Gamachot) are poorly preserved, but short and well separated. Also the pustulose radial ribs of the lateral areas seem more regular than the “pustulose ribs of irregularly arranged pustules on lateral areas and end valves” (Kaas & Van Belle, 1987: 43), typical of many *Chaetopleura* species, e.g. the three species compared by Cherns & Schwabe (2017) with *Chaetopleura abbessi* [*C. angulata* (Spengler, 1797), *C. asperrima* (Couthouy MS, Gould, 1852) and *C. isabellei* (d'Orbigny, 1841)]. Moreover, no species of *Chaetopleura* was found in the rich material studied from the Aquitaine Basin.

The generic attribution is however difficult. The tegmenum sculpture of the valve is weaker, but has strong similarities to species included in the genus *Lepidozona* Pilsbry, 1892, e.g. the species described by Vendrasco *et al.* (2012) from the Pliocene of California, and *Lepidozona* can be separated from *Ischnochiton* based mainly on weaker tegmental sculpture (Ferreira, 1974; Vendrasco *et al.*, 2012). The sculpture of the valve tegmenum of the genus *Ischnochiton* and *Lepidozona* is similar, and the two genera can be separated mainly on features of the articulamentum. The apophyses are not connected by a lamina in *Ischnochiton*, while in *Lepidozona* there is the presence of a delicately denticulate jugal lamina, separated from the apophyses on each side by small notch (Kaas & Van Belle, 1987), but unfortunately, these features are not visible in the valves examined. But the genus *Lepidozona* occurs in the Pacific and Indian Oceans, no species are known from Mediterranean Sea and fossils of *Lepidozona* are known only from latest Eocene/earliest Oligocene of Washington (Dell'Angelo *et al.*, 2011), Pliocene (Oinomikado, 1938) and Miocene of Japan (Itoigawa *et al.*, 1981), and Pliocene/Pleistocene of California (Berry, 1922; Vendrasco *et al.*, 2012).

For these reasons, we assign the valves to the genus *Ischnochiton*, on the basis of strong similarities to species included in this genus.

This new record for the species extend the stratigraphic



distribution of *Ischnochiton abbessi* to early Miocene (Burdigalian).

Distribution

**Late Oligocene:** northeastern Atlantic (Chattian): Aquitaine Basin, France (Cherns & Schwabe, 2017). **Early Miocene:** northeastern Atlantic (Burdigalian): Aquitaine Basin, France (this paper).

Genus *Stenosemus* von Middendorff, 1847

Type species

*Chiton albus* Linnaeus, 1767, by subsequent designation (Winckworth 1926).

Remarks

The genus *Stenosemus* is the most widely distributed genus of the order Chitonida, with 21 living described species (Sirenko, 2016), however fossil representatives of this genus are known only from the Neogene of Italy, *S. vanbellei* (Kaas, 1985), and *S. dolii* (Van Belle & Dell’Angelo, 1998).

Distribution

The genus is known from the Late Miocene to the Recent.

*Stenosemus dolii* (Van Belle & Dell’Angelo, 1998)  
(Figs 6D-F)

1977 *Lepidozona dorsuosa* (Haddon) - Laghi, p. 105, pl. 2, figs 1-4 (*fide* Dell’Angelo et al., 2012, *non* *Lepidopleurus dorsuosus* Haddon, 1886).  
1997 *Ischnochiton exaratus* (G.O. Sars) - Dell’Angelo & Giusti, p. 51, figs 4, 6, 9 (*fide* Dell’Angelo & Giusti, 2000, *non* *Lophyrus exaratus* Sars, 1878).  
1998 *Ischnochiton (Stenosemus) dolii* Van Belle & Dell’Angelo, p. 115, fig. 53, pls 36-38.  
1999 *Ischnochiton (Stenosemus) dolii* Van Belle & Dell’Angelo - Dell’Angelo & Smriglio, p. 115, pls 36-38, fig. 53).  
1999 *Ischnochiton (Simplischnochiton) exaratus* (Sars) - Dell’Angelo et al., p. 268, pl. 2, figs 2, 4-7, pl. 3, fig. 6 (*fide* Dell’Angelo et al., 2012, *non* *Lophyrus exaratus* Sars, 1878).  
2004 *Ischnochiton (Stenosemus) aff. vanbellei* Kaas - Dell’Angelo et al., p. 34, pl. 7, figs 2, 5-6 (*fide* Dell’Angelo et al., 2012, *non* *Ischnochiton (Stenosemus) vanbellei* Kaas, 1985).  
2012 *Stenosemus dolii* (Van Belle & Dell’Angelo) - Dell’Angelo et al., p. 58, figs 4A-K.  
2013 *Stenosemus dolii* Van Belle & Dell’Angelo - Dell’Angelo et al., p. 82, pl. 5, figs A-I.  
2015 *Stenosemus dolii* Van Belle & Dell’Angelo - Dell’Angelo et al., p. 235, pl. 6, figs 1-9.

Type material

Holotype: an intermediate valve, 3 x 7.5 mm (MZB 11302). Paratypes: MZB 11303 (five valves), IRSN IG 28523 (four valves), MNHN (three valves), and private collections.

Type locality

Tyrrhenian Sea, off Civitavecchia, Italy, in a Roman amphora (“dolium”) at a depth of 550 m (42°04’04”N, 11°45’31”E).

Material examined

**Late Miocene:** Amberre (Moulin-Pochas): 1 head valve, width 4 mm (PR).

Remarks

The species was described on the basis of many separate subfossil valves found in a Roman amphora (“dolium”) off Civitavecchia, at a depth of 550 meters (Van Belle & Dell’Angelo, 1998); other valves from a thanatocoenosis (death assemblage of accumulated fossils) from the South Ligurian Sea, between Corsica and Capraia Island, at a depth of 350-500 m were collected (Dell’Angelo & Giusti, 1997, 2000). Later live specimens from Thyrrenian Sea were found, at a depth between 150 and 480 m (Dell’Angelo & Smriglio, 1999; Dell’Angelo et al., 2001). This species present a great variability in the shape and sculpture of the valves, as reported by Dell’Angelo et al. (2012) who examined a large number of valves (n=315) from the Pliocene of Altavilla. This wide intra-specific variability permitted to Dell’Angelo et al. (2012) to attribute to *Stenosemus dolii* some additional records of this species reported as *Lepidozona dorsuosa*, *Ischnochiton exaratus* or *Ischnochiton* aff. *vanbellei* by Laghi (1977), Dell’Angelo & Giusti (1997), and Dell’Angelo et al. (1999, 2004). This new record for the species extend the stratigraphic distribution of *Stenosemus dolii* to the late Miocene of the Ligerian Basin.

Comparisons

The only other fossil record of the genus *Stenosemus* is *S. vanbellei* (Kaas, 1985), known from the Pleistocene of Italy and living in Mediterranean Sea and Atlantic Ocean (off Mauritania). The latter species differs from *S. dolii* by the different sculpture, with longitudinal sulci in central areas of intermediate valves and antemucronal area of tail valves (Dell’Angelo & Smriglio, 1999, table p. 116).

Distribution

**Late Miocene:** northeastern Atlantic (Messinian?): Ligerian Basin, France (this paper); Proto-Mediterranean Sea (Tortonian and Messinian): Po Basin, N Italy (Dell’Angelo et al., 1999, 2015). **Pliocene:** western Mediterranean, Estepona Basin, Spain (Dell’Angelo et al., 2004); central Mediterranean, Italy (Dell’Angelo et al., 2012, 2013). **Pleistocene:** central Mediterranean, Italy: valves dredged between Capraia and Capo Corso, at a depth of 350-500 m (Van Belle & Dell’Angelo, 1998;



Dell'Angelo & Giusti, 1997, 2000). **Recent:** Mediterranean Sea, off the Latium coast and in the Tuscan Archipelago, between 150 and 560 m, and in association with white coral biocoenosis (Dell'Angelo & Smriglio, 1999).

Genus *Connexochiton* Kaas, 1979

### Type species

*Connexochiton platynomenus* Kaas, 1979, by original designation.

### Remarks

Only one species is known as fossil, from the Pliocene of Borzoli (Liguria, Italy), *Connexochiton roccai* Dell'Angelo, Sosso, Prudenza & Bonfitto, 2013.

### Diagnosis

Of very small size, elongate oval, tegmental sculpture granulose, slit formula many / 1 / many, teeth short, propped, apophyses connected by a lamina, without notches in between, girdle covered with imbricating, striated scales (Kaas & Van Belle, 1987: 257).

### Distribution

The genus is known from the Pliocene to the Recent, with five species known from the Atlantic and Pacific Oceans.

*Connexochiton vivesi* n. sp.  
(Figs 6G-L)

### Type material

Holotype: MHNbX 2017.6.1, a tail valve (ex JFL), width 4 mm (Figs 6G-L).

### Type locality

Meilhan (Carrière Vives 9).

### Type stage

Miocene, Burdigalian.

### Etymology

The name honours Mr. Vives, owner of the Vives quarry, who has allowed paleontological research on his outcrop since the 1980s.

### Description

Head and intermediate valves not known.

Tail valve small, semicircular, the length about half the width, rather flat, anterior margin slightly convex, mucro situated anteriorly, not prominent, antemucronal slope almost straight, postmucronal slope slightly concave just underneath mucro and quite straight posterior from there.

Tegmentum rather coarsely granulose on postmucronal area, with granules arranged in segments of various size and orientation, slightly overlapping each other forming rugosities. On antemucronal area, granules fused forming fine network.

Apophyses rounded, wide, connected across jugal portion. Insertion plate thick, eaves solid, central depression with numerous transverse slits in jugal tract, teeth eroded and scarcely visible, but 28 well marked slits rays are present.

### Remarks

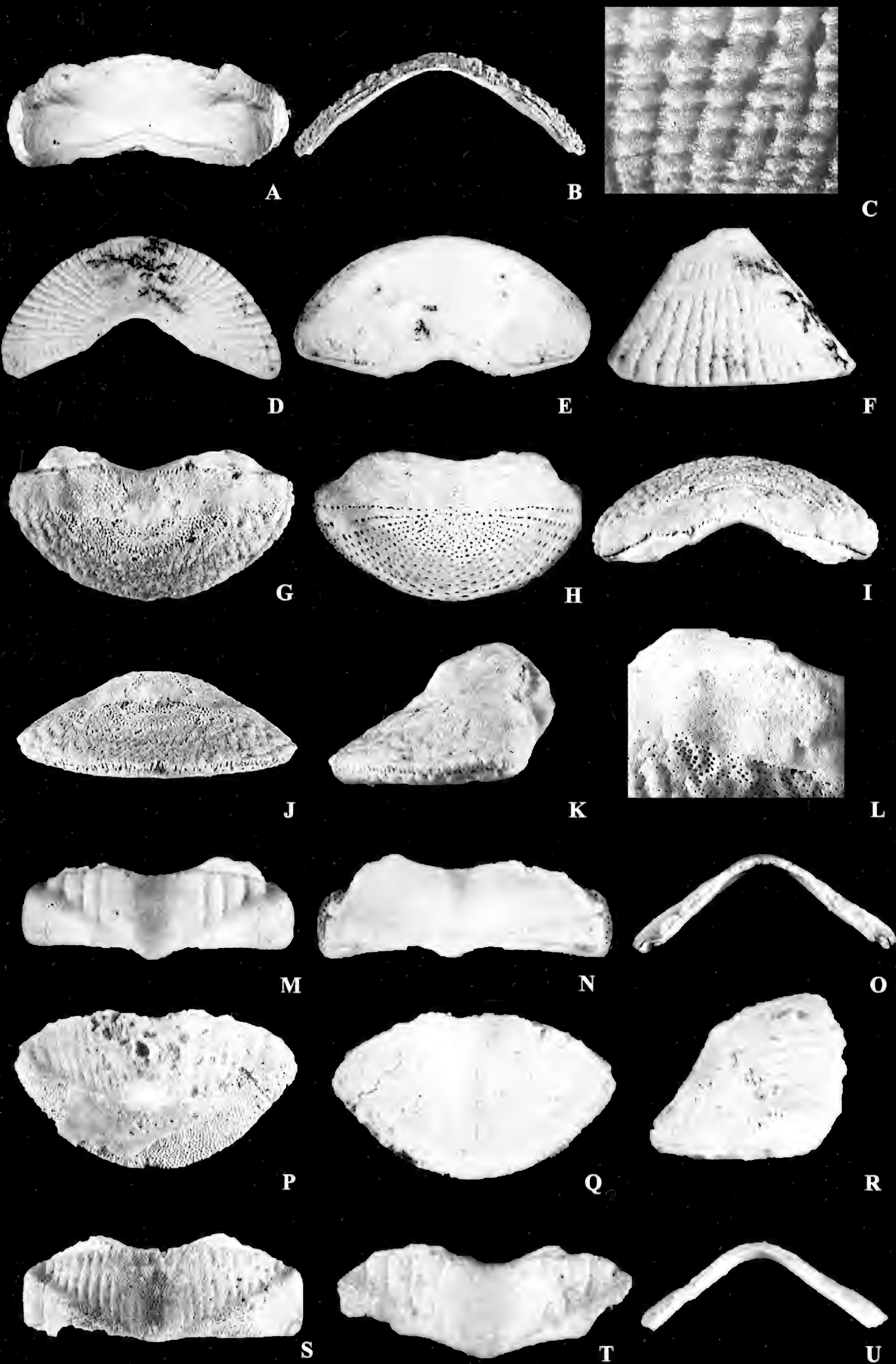
The characteristic features of the unique tail valve warrant the assignment of this species to *Connexochiton*. The valve is partly eroded, also the apophyses are not complete, but the connection by a lamina is still visible. Also the posterior margin is eroded, the incisions are barely outlined and hardly visible.

Other genera show the apophyses connected across the jugal portion, but all these have characteristics not agreeing with the present valve e.g., *Callochiton* Gray, 1847 (with a finely granulose sculpture, eaves spongy, extra-pigmentary eyes present), *Lepidozona* Pilsbry, 1892 (with a jugal plate notched at the sides, and a different tegmental sculp-

**Fig. 6. A-C.** *Ischnochiton abbessi* Cherns & Schwabe, 2017, Noaillan (Gamachot), France, Aquitaine Basin, Miocene (Burdigalian), MHNbX 2017.9.2, intermediate valve (ex BD), width 7.8 mm. **A-B.** Ventral and frontal views. **C.** Detail of the sculpture. **D-F.** *Stenosemus dolii* (Van Belle & Dell'Angelo, 1998), Amberre (Moulin-Pochas), France, Ligerian Basin, Miocene (Messinian?), head valve, width 4 mm, dorsal, ventral and lateral views (PR). **G-L.** *Connexochiton vivesi* n. sp., Meilhan (Carrière Vives 9), France, Aquitaine Basin, Miocene (Burdigalian), Holotype, MHNbX 2017.6.1, tail valve (ex JFL), width 4 mm. **G-K.** Dorsal, ventral, frontal, posterior and lateral views. **L.** Detail of the sculpture. **M-U.** *Rhyssoplax corallinus* (Risso, 1826), France, Aquitaine Basin. **M-O.** Martillac (coupe du fossé près de la Solitude), Miocene (Burdigalian), intermediate valve, width 2.4 mm, dorsal, ventral and frontal views (JFL). **P-S.** Orthez (Le Paren), Miocene (Serravallian). **P-R.** Tail valve, width 4 mm, dorsal, ventral and lateral views (BD). **S.** Intermediate valve, width 6 mm, dorsal view (BD). **T-U.** Saint-Paul-lès-Dax (Abesse RG), Oligocene (Chattian), intermediate valve, width 1.4 mm, dorsal and frontal views (DA).

**Fig. 6. A-C.** *Ischnochiton abbessi* Cherns & Schwabe, 2017, Noaillan (Gamachot), Francia, Bacino Aquitaniano, Miocene (Burdigaliano), MHNbX 2017.9.2, piastra intermedia (ex BD), larghezza 7,8 mm. **A-B.** Viste ventrale e frontale. **C.** Dettaglio della scultura. **D-F.** *Stenosemus dolii* (Van Belle & Dell'Angelo, 1998), Amberre (Moulin-Pochas), Francia, Bacino Ligeriano, Miocene (Messiniano?), piastra anteriore, larghezza 4 mm, viste dorsale, ventrale e laterale (PR). **G-L.** *Connexochiton vivesi* n. sp., Meilhan (Carrière Vives 9), Francia, Bacino Aquitaniano, Miocene (Burdigaliano), Olotipo, MHNbX 2017.6.1, piastra posteriore (ex JFL), larghezza 4 mm. **G-K.** Viste dorsale, ventrale, frontale, posteriore e laterale. **L.** Dettaglio della scultura. **M-U.** *Rhyssoplax corallinus* (Risso, 1826), Francia, Bacino Aquitaniano. **M-O.** Martillac (coupe du fossé près de la Solitude), Miocene (Burdigaliano), piastra intermedia, larghezza 2,4 mm, viste dorsale, ventrale e frontale (JFL). **P-S.** Orthez (Le Paren), Miocene (Serravalliano). **P-R.** Piastra posteriore, larghezza 4 mm, viste dorsale, ventrale e laterale (BD). **S.** Piastra intermedia, larghezza 6 mm, vista dorsale (BD). **T-U.** Saint-Paul-lès-Dax (Abesse RG), Oligocene (Chattiano), piastra intermedia, larghezza 1,4 mm, viste dorsale e frontale (DA).







ture), *Chaetopleura* Shuttleworth, 1853 (with a tegmental sculpture usually consisting of pustules).

The valve's characters are distinctive and well defined, and for these reasons, and also considering the rare records of this genus as a fossil, we have described this single tail valve as a new species.

## Comparisons

Only one fossil species of *Connexochiton* is known from the Pliocene of Liguria, *C. roccai* Dell'Angelo, Soso, Prudenza & Bonfitto, 2013, also described based on a unique tail valve. This species has a granulose sculpture with some resemblance to *C. vivesi*, but the pattern is opposite, with the network in postmucronal area and irregular concentric wrinkles in antemucronal one.

Five species of living *Connexochiton* are known, including three from the Atlantic [*C. moreirai* (Righi, 1973), *C. platynomenus* Kaas, 1979, and *C. bromleyi* (Ferreira, 1985)], and two from the Pacific (*C. discernibilis* Kaas, 1991, and *C. kaasi* Saito, 1997). The three Atlantic species have a strong granulose sculpture on the whole tegmentum, and *C. discernibilis* has a sculpture of radial grooves and a series of wavy depressions. Only *C. kaasi* has a granulose sculpture with some resemblance with the new species from Meilhan, but the sculpture is coarser in antemucronal area, with granules fused laterally and forming numerous irregular concentric wrinkles in postmucronal area.

## Distribution

**Early Miocene:** northeastern Atlantic (early Burdigalian): Aquitaine Basin, France (this paper).

Family Chitonidae Rafinesque, 1815  
Subfamily Chitoninae Rafinesque, 1815  
Genus *Rhyssoplax* Thiele, 1893

## Type species

*Chiton affinis* Issel, 1869, by subsequent designation (International Committee of Zoological Nomenclature, 1971, Opinion 951, as proposed by Beu et al., 1969).

## Remarks

The genus *Chiton* has been subdivided in many subgenus (Kaas et al., 2006), some of which (e.g. *Rhyssoplax* Thiele, 1893) were considered by Sirenko (2006) separate genus from *Chiton*, mainly based on the soft parts of living specimens. In our material is present one species still living of *Rhyssoplax*, and so we can maintain the attribution to this genus for the fossil material.

## Distribution

The genus is known from the Oligocene to the present-day. Tropical and subtropical waters of the indo-Pacific (except for the East Pacific), also in the Eastern Atlantic. The fossil record extends back to the Oligocene

of New Zealand (Dell'Angelo et al., 2011), the Neogene of Europe (Dell'Angelo et al., 2004, 2015; Garilli et al., 2005; Studencka & Dulai, 2010), Africa (Algeria: De Lamothe, 1911; Tunisia: Castany et al., 1956), New Zealand (Beu & Maxwell, 1990) and Japan (Itoigawa et al., 1976).

## *Rhyssoplax corallinus* (Risso, 1826) (Figs 6M-U)

1826 *Lepidopleurus corallinus* Risso, p. 268.

Additions to the bibliography in Dell'Angelo et al. (2016: 78):  
2016 *Chiton corallinus* (Risso) - Dell'Angelo et al., p. 78, pl. 2, figs 1-15.

## Type material

Presumed lost, not present in the Risso collection, MNHN (*vide* Arnaud, 1977).

## Type locality

Nice, France (43°41'09"N, 7°15'52"E).

## Material examined

**Chattian, Late Oligocene:** Saint-Paul-lès-Dax (Abesse RG): 2 valves (1 intermediate and 1 tail) (DA).

**Aquitanian:** Saint-Paul-lès-Dax (Maïnot): 3 valves (1 intermediate and 2 tail) (JFL).

**Burdigalian:** Meilhan: 5 valves (3 intermediate and 2 tail) (BD); Martillac (coupe du fossé près de la Solitude): 2 intermediate valves (JFL); Saint-Jean-de-Marsacq (Lahitet): 13 intermediate valves (AC, JFL, PR).

**Serravallian:** Orthez (Le Paren): 2 valves (1 intermediate and 1 tail); Sallespisse (Carré): 1 intermediate valve (PR).

**Late Miocene:** Amberre (Moulin-Pochas): 5 intermediate valves (PR).

Maximum width: -- / 7.6 / 3.2 mm.

## Remarks

Detailed descriptions of this species are in Dell'Angelo & Smriglio (1999) and Kaas et al. (2006). The species is characterized by having a smooth surface of the head valve, the lateral areas of the intermediate valves and the postmucronal area of the tail valve, while the pleural areas are sculptured on each side by 5-10 small outward-leaning folds of tegmentum.

The valves found are for the most part in poor conditions of preservation, and the characters correspond well to those typical of this species.

These new records for the species extend the stratigraphic distribution of *Rhyssoplax corallinus* to the Late Oligocene (Chattian).

## Comparisons

The main differential characters from the other similar *Rhyssoplax* species known from the Neogene of Italy (*R.*



*olivaceus* Spengler, 1797, and *R. miocenicus* Michelotti, 1847) are reported by Dell'Angelo et al. (2013, tab. 1 p. 84). Another similar species is *Rhyssoplax sulcomarginatus* Dell'Angelo, Giuntelli, Sosso & Zunino, 2016, which differs from *R. corallinus* by the presence of 3-4 small scars obliquely directed, in pleural and antemucronal areas near the side margin, and of some light ribs only in a small part near the margins of head valve, and lateral and postmucronal areas (Dell'Angelo et al., 2016: 82, pl. 3, figs 5-12).

## Distribution

**Late Oligocene:** northeastern Atlantic (Chattian): Aquitaine Basin, France (this paper). **Early Miocene:** northeastern Atlantic (Aquitainian/Burdigalian): Aquitaine Basin, France (this paper); Proto-Mediterranean Sea (Burdigalian): Turin Hill, Italy (Dell'Angelo et al., 2016); **Middle Miocene:** northeastern Atlantic (Serravallian): Aquitaine Basin, France (this paper); Proto-Mediterranean Sea (Langhian): Po Basin, N Italy (Dell'Angelo et al., 2016); Paratethys (Langhian-Serravallian): central-eastern Europe (Studencka & Studencki, 1988; Studencka & Dulai, 2010); **Late Miocene:** northeastern Atlantic (Messinian?): Ligerian Basin, France (this paper); Proto-Mediterranean Sea (Tortonian-Messinian): Po Basin, N Italy (Laghi, 1977; Dell'Angelo et al., 1999, 2016). **Pliocene:** northeastern Atlantic, Mondego Basin, Portugal (Dell'Angelo & Silva, 2003); western Mediterranean, Estepona Basin, Spain (Dell'Angelo et al., 2004); central Mediterranean, Italy (Dell'Angelo et al., 2001, 2013; Chirli, 2004; Sosso & Dell'Angelo, 2010). **Pleistocene:** central Mediterranean, Italy (Dell'Angelo et al., 2001, 2007), Greece (Garilli et al., 2005; Koskeridou et al., 2009). **Recent:** Mediterranean Sea and the northern part of the Atlantic coast of Morocco (Dell'Angelo & Smriglio, 1999; Kaas et al., 2006).

*Rhyssoplax assurrectum* Dell'Angelo, Landau,  
Van Dingenen & Ceulemans, 2018  
(Figs 7A-D)

2013 *Chiton* sp. A - Dell'Angelo et al., p. 88, pl. 7, figs I-J.  
2018 *Rhyssoplax assurrectum* Dell'Angelo, Landau, Van Dingenen & Ceulemans, p. xx, fig. 18.

## Type material

Holotype MNHN.F.A67124, an intermediate valve (Dell'Angelo et al., 2018: figs 18A-C). Paratypes 1-4: MNHN.F.A67125-A67128; Paratypes 5-8: NHMW 2017/0108/0033-0036; Paratypes 9-12: RGM.1008368-1008371.

## Type locality

Saint-Clément-de-la-Place, France.

## Type stage

Miocene (Tortonian).

## Material examined

**Aquitainian:** Saint-Paul-lès-Dax (Maïnot): 1 intermediate valve, width 5.5 mm (PR).

**Burdigalian:** Meilhan: 1 intermediate valve, width 2.5 mm (BD).

**Late Miocene:** Amberre (Moulin-Pochas): 1 intermediate valve, width 5.5 mm (PR).

## Remarks

*Rhyssoplax assurrectum*, recently described from the Miocene (Tortonian) of Anjou, France (Dell'Angelo et al., 2018) is close to *Rhyssoplax corallinus*, from which differs mainly by the more elevated intermediate valves ( $H/W = 0.53-0.56$  vs  $0.3-0.4$  in *R. corallinus*), and the different shape of the tail valve ( $L/W = 0.62-0.66$  vs.  $0.51$  in *R. corallinus*). The three intermediate valves examined from the Aquitaine and Ligerian Basins have a similar degree of dorsal elevation ( $H/W = 0.52-0.58$ ), and can therefore be attributed to *Rhyssoplax assurrectum*, as well as the intermediate valves reported from the Pliocene of Liguria as *Chiton* sp. A (Dell'Angelo et al., 2013: pl. 7, figs I-J) ( $H/W = 0.5-0.65$ ).

These new records for the species extend the stratigraphic distribution of *Rhyssoplax assurrectum* to the early Miocene (Aquitainian/Burdigalian).

## Distribution

**Early Miocene:** northeastern Atlantic (Aquitainian/Burdigalian): Aquitaine Basin, France (this paper); **Late Miocene:** northeastern Atlantic (Tortonian): Anjou, France (Dell'Angelo et al., 2018); northeastern Atlantic (Messinian?): Ligerian Basin, France (this paper). **Pliocene:** central Mediterranean, Italy (Dell'Angelo et al., 2013).

Subfamily Toniciinae Pilsbry, 1893  
Genus *Lucilina* Dall, 1882

## Type species

*Chiton confossus* Gould, 1846 (= *Chiton lamellosus* Quoy & Gaimard, 1835), by subsequent designation (Pilsbry, 1893).

## Remarks

Following the suggestions of some authors (e.g. Strack, 2003; Schwabe, 2004, 2006; Schwabe et al., 2008; Schwabe & Pittman, 2014), the genus *Lucilina* is here considered as a separate genus, and not as a subgenus of *Tonicia* Gray 1847. It differs from the latter mainly in having a multi-dentate second lateral tooth in the radula, whereas it is unicuspidate in *Tonicia* (Schwabe et al., 2008, p. 24), and by the position of the mucro in tail valve, subterminal in *Lucilina* and subcentral in *Tonicia* (Kaas et al., 2006, p. 294). Moreover the species of *Tonicia* are geographically restricted to the South Eastern Pacific region of Latin America with a single species in the Caribbean, while members of *Lucilina* are widespread throughout the tropical Indo-Pacific.



## Distribution

The genus is known from the Miocene to the Recent.

*Lucilina saubadeae* n. sp.  
(Figs 7E-L)

## Type material

Holotype: MHNbX 2017.10.1, a tail valve (ex DA), width 3.6 mm (Figs 7E-I). Paratype: MZB 32136, a tail valve (ex PR), width 4.6 mm (Figs 7J-L).

## Type locality

Gaas (Espibos).

## Type stage

Oligocene (Rupelian)

## Etymology

In honour of Mme Anne-Marie Vergneau-Saubade who produced two theses and numerous publications on Oligocene molluscs from Gaas.

## Other material

**Oligocene, Rupelian:** Gaas (Espibos): 3 tail valves, maximum width 5 mm (AC, DA, PR).

## Description

Head and intermediate valves not known.

Tail valve almost semicircular, the length ca. half the width, anterior margin about straight, mucro small, raised, in posterior position, antemucronal slope concave, postmucronal slope steep, straight to weakly convex, antemucronal area sculptured with oval, elevated granules, jugal area eroded.

Articulamentum with apophyses well developed, broad, jugal sinus narrow, ca. 8-9 teeth relatively long, solid, forwardly directed.

## Remarks

The shape of the tail valves examined and the presence of a subterminal mucro are consistent with the genus *Lucilina* (Kaas *et al.*, 2006: 294) and, despite the bad preservation of the valves, and also considering that this is the first record of this genus in the European Tertiary, we have described these tail valves as a new species. The teeth in insertion plates are worn, so it is not possible to see if they are pectinated or not, as pectinated insertion plates are diagnostic for Chitonidae.

The fossil record of the genus *Lucilina* is poorly known. Two species, *Lucilina nigropunctata* (Carpenter, 1865) and *L. russelli* Ladd, 1966 are known from the Pliocene and Miocene of the W. Pacific islands (Ladd, 1966; Schwabe *et al.*, 2008). *Lucilina sueziensis* (Reeve, 1847), a common species living in the Red Sea and Indian Ocean, is known from the Pleistocene of Red Sea (Issel, 1869, and unpublished data).

Other species of chitons known from the Eocene of France were attributed to *Tonicia* in the past and included in compendia based on literature and historical identifications (Dell'Angelo *et al.*, 2011, Appendix 2), one from the Paris Basin (*T. edwardsi* de Rochebrune, 1882, see Pacaud & Le Renard, 1995), and other from the Cotentin Basin, but there are no recent revisions of these species reported in the literature, the original descriptions are often inadequate, and so these species cannot be attributed with confidence to a specific genus, and are thus considered *gen. inquir.*

The only species from the European Cenozoic attributed with certainty to *Tonicia* is *T. pannonica* Szöts, 1953 from the middle Eocene of Gant, Hungary, recently re-examined by Dell'Angelo *et al.* (2015), characterized by a smooth tegmentum and the presence of regular rows of subcircular ocelli.

## Distribution

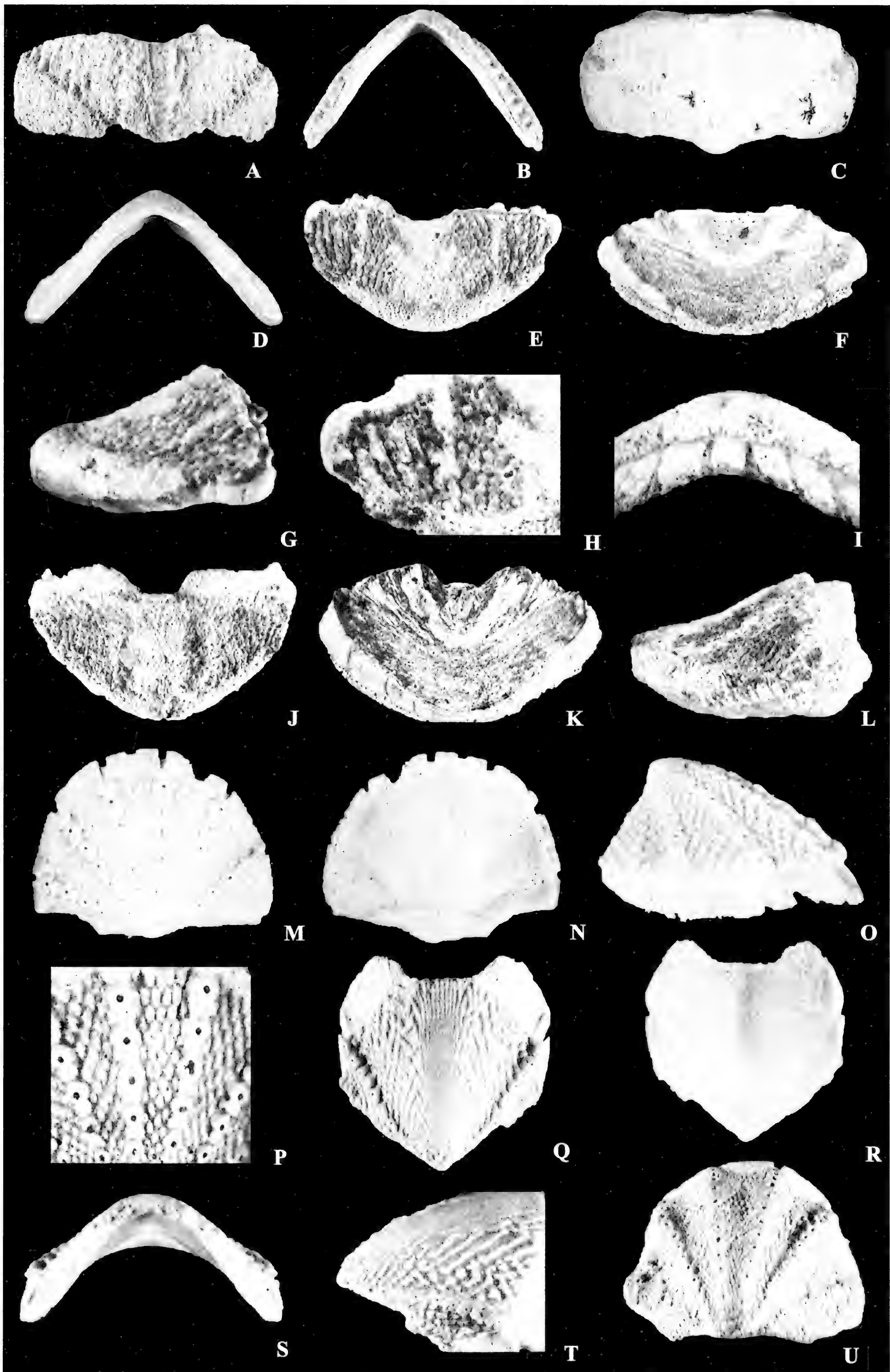
**Middle Oligocene:** northeastern Atlantic (Rupelian): Aquitaine Basin, France (this paper).

Family Spinochitonidae new family

**Fig. 7. A-D.** *Rhyssoplax assurrectum* Dell'Angelo, Landau, Van Dingenen & Ceulemans, 2018. **A-B.** Saint-Paul-lès-Dax (Mâinot), France, Aquitaine Basin, Miocene (Aquitainian), intermediate valve, width 5.5 mm, dorsal and frontal views (PR). **C-D.** Amberre (Moulin-Pochas), France, Ligerian Basin, Miocene (Messinian?), intermediate valve, width 5.5 mm, dorsal and frontal views (PR). **E-L.** *Lucilina saubadeae* n. sp., Gaas (Espibos), France, Aquitaine Basin, Oligocene (Rupelian). **E-I.** Holotype, MHNbX 2017.10.1, tail valve (ex DA), width 3.6 mm. **E-G.** Dorsal, ventral and lateral views. **H.** Detail of the sculpture. **I.** Detail of teeth of insertion plate. **J-L.** Paratype, MZB 32136, tail valve (ex PR), width 4.6 mm, dorsal, ventral and lateral views. **M-U.** *Schizochiton tasteti* n. sp., Gaas (Lagouarde), France, Aquitaine Basin, Oligocene (Rupelian). **M-P.** Holotype, MHNbX 2017.7.4, head valve (ex AC), width 2.3 mm. **M-O.** Dorsal, ventral and lateral views. **P.** Detail of the sculpture. **Q-T.** Paratype, MHNbX 2017.7.5, intermediate valve (ex AC), width 4.4 mm. **Q-S.** Dorsal, ventral and frontal views. **T.** Detail of the sculpture. **U.** Head valve, 5.2 mm, dorsal view (AC).

**Fig. 7. A-D.** *Rhyssoplax assurrectum* Dell'Angelo, Landau, Van Dingenen & Ceulemans, 2018. **A-B.** Saint-Paul-lès-Dax (Mâinot), Francia, Bacino Aquitaniano, Miocene (Aquitainiano), piastra intermedia, larghezza 5,5 mm, viste dorsale e frontale (PR). **C-D.** Amberre (Moulin-Pochas), Francia, Bacino Ligeriano, Miocene (Messiniano?), piastra intermedia, larghezza 5,5 mm, viste dorsale e frontale (PR). **E-L.** *Lucilina saubadeae* n. sp., Gaas (Espibos), Francia, Bacino Aquitaniano, Oligocene (Rupeliano). **E-I.** Olotipo, MHNbX 2017.10.1, piastra posteriore (ex DA), larghezza 3,6 mm. **E-G.** Viste dorsale, ventrale e laterale. **H.** Dettaglio della scultura. **I.** Dettaglio dei denti della placca di inserzione. **J-L.** Paratype, MZB 32136, piastra posteriore (ex PR), larghezza 4,6 mm, viste dorsale, ventrale e laterale. **M-U.** *Schizochiton tasteti* n. sp., Gaas (Lagouarde), Francia, Bacino Aquitaniano, Oligocene (Rupeliano). **M-P.** Olotipo, MHNbX 2017.7.4, piastra anteriore (ex AC), larghezza 2,3 mm. **M-O.** Viste dorsale, ventrale e laterale. **P.** Dettaglio della scultura. **Q-T.** Paratipo, MHNbX 2017.7.5, piastra intermedia (ex AC), larghezza 4,4 mm. **Q-S.** Viste dorsale, ventrale e frontale. **T.** Dettaglio della scultura. **U.** Piastra anteriore, larghezza 5,2 mm, vista dorsale (AC).







## Type genus

*Spinochiton* new genus.

## Diagnosis

Chitons of small size, head valve elevated with apex slightly recurved and front slope concave, tegmentum sculptured with radial rows of conical spinous processes on head valve and lateral areas of intermediate valves, with longitudinal ribs with oval pustules more or less fused together on central areas of intermediate valves, insertion plates pectinated, apical area large, extending obliquely to the articulamentum, apophyses connected by a jugal lamina with external slits.

## Occurrence

Known only from the middle Oligocene (Rupelian) of Gaas, Aquitaine Basin (France).

## Remarks

The species found at Gaas has a number of main characters that can be useful for the supraspecific assignment. One of them (insertion plates pectinated) allow us to assign the species to the Superfamily Chitonoidea. The head valve elevated with apex slightly recurved and front slope strongly concave is a character present in some chiton species, e.g. *Oochiton halli* Ashby, 1929 from the Miocene of Balcombe Bay, near Mornington, Victoria, Australia. The genus *Oochiton* is inserted in the Superfamily Chitonoidea Rafinesque, 1815 - Family Loricidae Iredale & Hull, 1923 (Sirenko, 2006).

The apical area large and extending obliquely to the articulamentum is not a character present in chitons from Tertiary, where the apical area is normally little evident in head valve, and more pronounced but always narrow in intermediate ones.

Also the spinous processes are, at our knowledge, not present in other chiton species.

The apophyses connected by a jugal lamina with external slits are typical of the genus *Lepidozona* Pilsbry, 1892, inserted in the Superfamily Chitonoidea Rafinesque, 1815 - Family Ischnochitonidae Dall, 1889 (Sirenko, 2006). Based on the characters highlighted, the establishment of a new family included in Superfamily Chitonoidea Rafinesque, 1815 seems therefore appropriate.

Genus *Spinochiton* new genus

## Type species

*Spinochiton gaasi* (Cherns & Schwabe, 2017).

## Diagnosis

As for new family.

## Occurrence

Known only from the Middle Oligocene (Rupelian) of Gaas, Aquitaine Basin (France).

## Etymology

The name refers to the sculpture of radial rows of conical spinous processes.

## Remarks

During the study of the rich material from the Oligocene (Rupelian) of Gaas, a sixty valves have been examined with characteristics such as to establish the new family and the new genus described here. Before the publication of our work, this species has been described by Cherns & Schwabe (2017) as *Chaetopleura gaasi* from the same locality, based on four valves (1 head and 3 tail) deposited at ZSM, poorly preserved, and for this reason the authors could not highlight some of the peculiar diagnostic features of this species. The generic assignment of this species is changed from *Chaetopleura* to *Spinochiton* n. gen. herein, based on the diagnostic features of the new material studied

*Spinochiton gaasi* (Cherns & Schwabe, 2017) n. comb.  
(Figs 8A-U, 9A-L)

2008 *Chiton* sp. 2. - Varone, p. 157, figs 15-16.

2017 *Chaetopleura gaasi* Cherns & Schwabe, 2017, p. 8, figs 6A-I.

## Type material

Holotype ZSM Mol 20060779A, a tail valve (Cherns & Schwabe, 2017: figs 6A-C, G). Paratype ZSM Mol 20060779D, an head valve (Cherns & Schwabe, 2017: figs 6D-F, H-I).

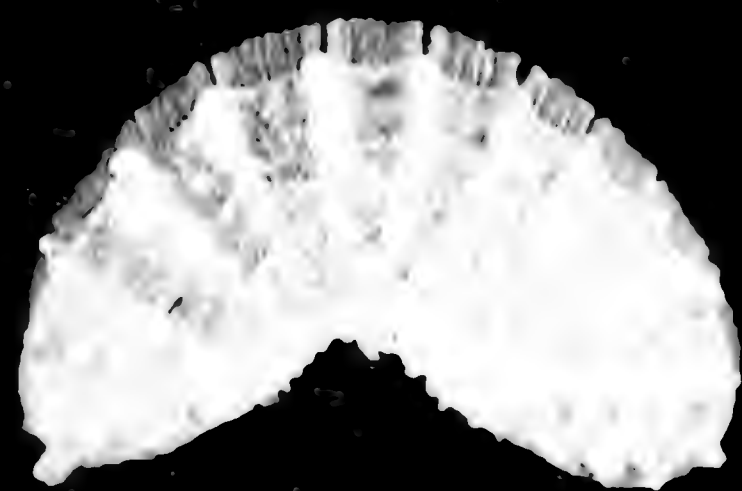
## Type locality

Gaas.

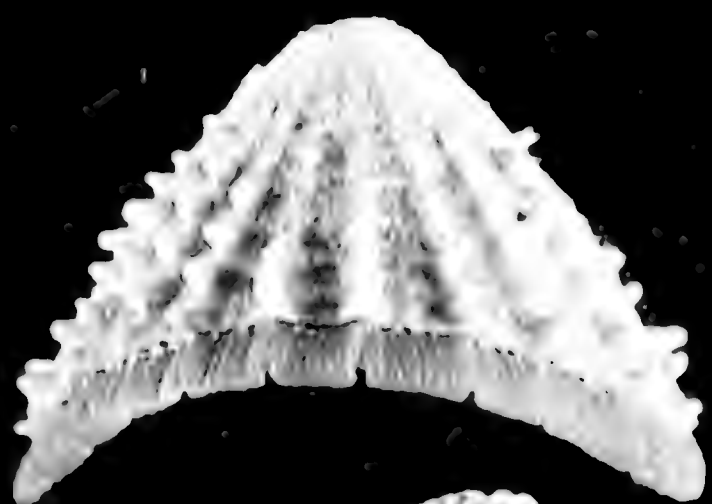
**Fig. 8. A-U.** *Spinochiton gaasi* (Cherns & Schwabe, 2017), Gaas (Larrat), France, Aquitaine Basin, Oligocene (Rupelian). **A-I.** MHNbX 2017.7.3, head valve (ex AC), width 5 mm. **A-B.** Dorsal views. **C.** Ventral view. **D-E.** Lateral views. **F.** Posterior view. **G-H.** Details of apical area. **I.** Details of the sculpture and pectinated insertion plates. **J-L.** Intermediate valve, width 6 mm, dorsal, ventral and frontal views (DA). **M-U.** MHNbX 2017.10.2, intermediate valve (ex DA), width 5.4 mm. **M-N.** Dorsal and ventral views. **O.** Details of the jugal lamina connecting the apophyses. **P.** Frontal view. **Q.** Details of apical area. **R-S.** Details of the sculpture. **T.** Broken spinuous processes, with a visible hole in the center position. **U.** Details of the sculpture.

**Fig. 8. A-U.** *Spinochiton gaasi* (Cherns & Schwabe, 2017), Gaas (Larrat), Francia, Bacino Aquitaniano, Oligocene (Rupeliano). **A-I.** MHNbX 2017.7.3, piastra anteriore (ex AC), larghezza 5 mm. **A-B.** Viste dorsali. **C.** Vista ventrale. **D-E.** Viste laterali. **F.** Vista posteriore. **G-H.** Dettaglio dell'area apicale. **I.** Dettaglio della scultura e della placca di inserzione pettinata. **J-L.** Piastra intermedia, larghezza 6 mm, viste dorsale, ventrale e frontale (DA). **M-U.** MHNbX 2017.10.2, piastra intermedia (ex DA), larghezza 5,4 mm. **M-N.** Viste dorsale e ventrale. **O.** Dettaglio della lamina jugale che collega le apofisi. **P.** Vista frontale. **Q.** Dettaglio dell'area apicale. **R-S.** Dettaglio della scultura. **T.** Processi spinosi rotti, con un foro visibile in posizione centrale. **U.** Dettaglio della scultura.





A



B



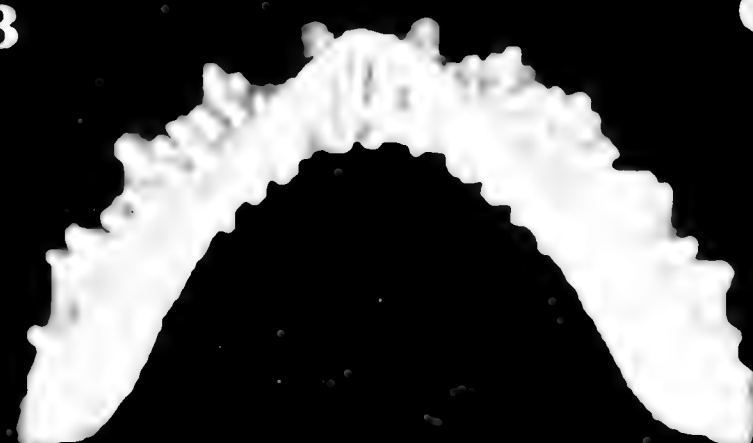
C



D



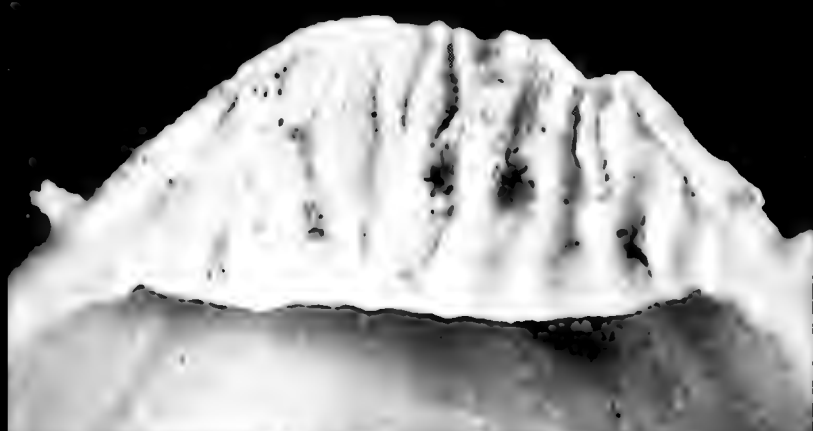
E



F



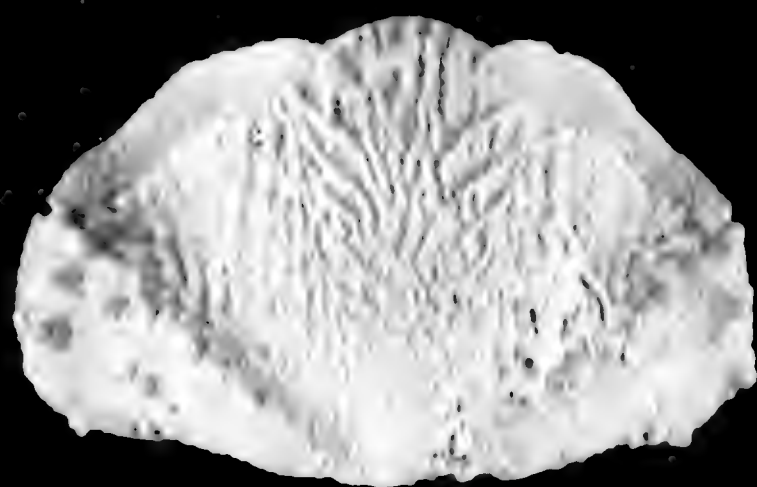
G



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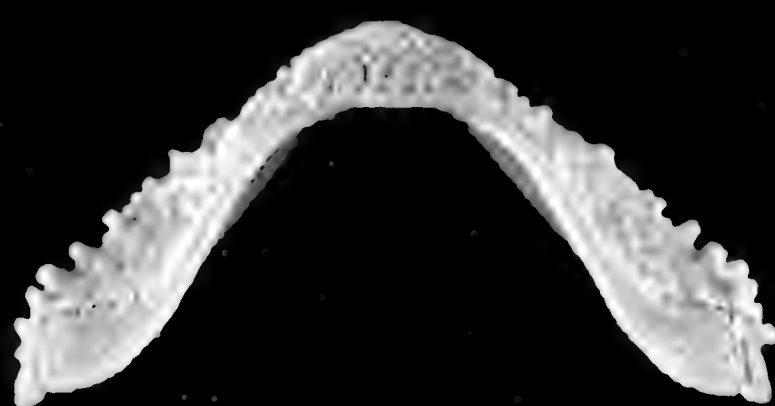
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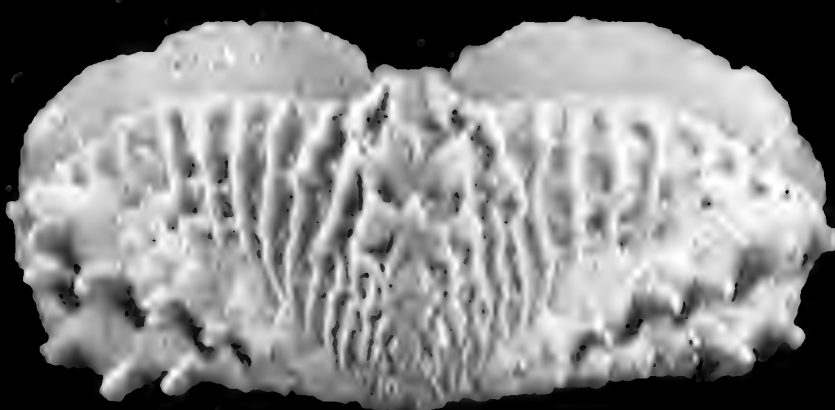
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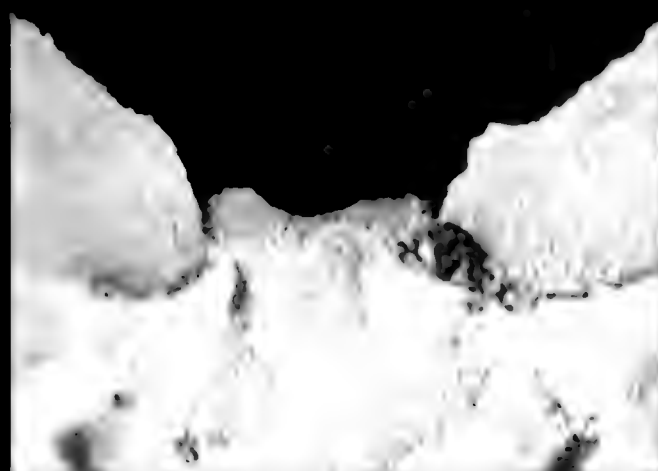
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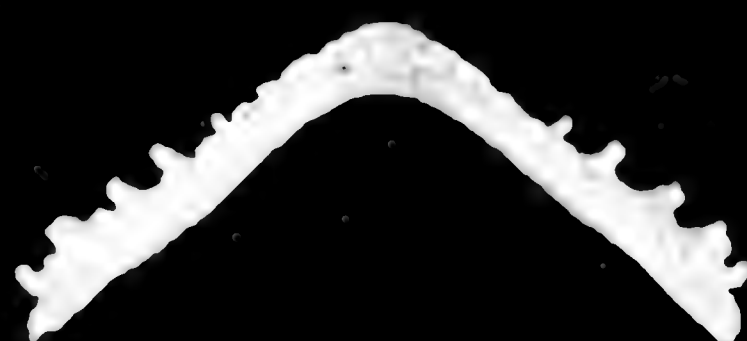
M



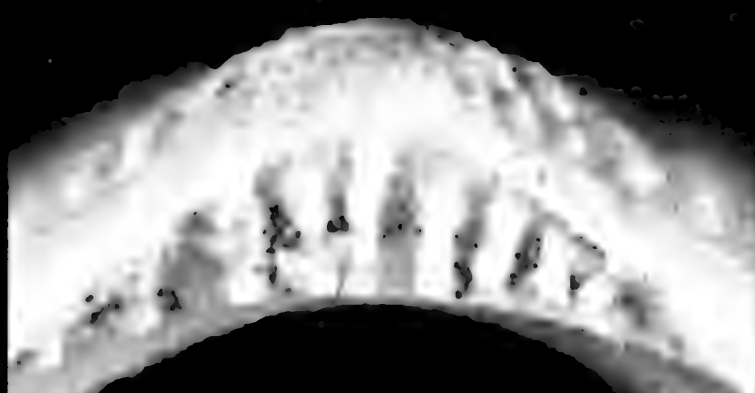
N



O



P



Q



R



S



T



U



## Type stage

Oligocene (Rupelian).

## Other material

**Oligocene, Rupelian:** Gaas (Espibos): 6 valves (2 head, 2 intermediate and 2 tail) (AC, DA); Gaas (Lagouarde): 4 valves (2 head and 2 intermediate) (AC, DA); Larrat: MHNbX 2017.7.3, an head valve (ex AC), width 5 mm (Figs 8A-I); MHNbX 2017.10.2, an intermediate valve (ex DA), width 5.4 mm (Figs 8M-U); MHNbX 2017.11.1, a tail valve (ex JVC), width 5.3 mm (Figs 9A-F); 47 valves (8 head, 36 intermediate and 3 tail) (AC, DA, JVC). Maximum width: 6.2 / 8.6 / 5.7 mm.

## Description

We give a complete description of an intermediate valve (MHNbX 2017.10.2, Figs 9A-F), lacking in the material studied by Cherns & Schwabe (2017), and some additional informations on some characters not clearly evidenced in the material studied by Cherns & Schwabe (2017).

## Intermediate valve

Intermediate valve (Figs 9A-F) rectangular ( $L/W = 0.43$ ), carinate, moderately elevated ( $H/W = 0.40$ ), anterior margin convex with jugal part forwardly produced, side margins oblique, posterior margin straight, apex inconspicuous, lateral areas slightly raised with 2 radial rows of conical spinous processes rounded at the top, like in head valve, obsolete near the apex and growing towards the side margins, one of them on the posterior margin. Central area with longitudinal coarse ribs with from 2 to 6 very irregular oval pustules, getting larger and fused together towards the jugal area, the latter formed by a single longitudinal rib with the larger pustules fused together to reach the two adjacent ribs. Interspaces with growth lines vaguely indicated, intersected by very small and fine striae of longitudinal granules, giving a reticulate appearance.

### *Sculpture of radial rows of conical spinous processes.*

Also the sculpture of the head valve is represented by radial rows (14 in the Holotype, 13 in Fig. 8A) of conical spinous processes rounded at the top (without any type of sculpture), the rows starting from a small smooth area around the semicircular notch with the spinous processes initially small and growing and getting more elevate towards the anterior margin, 6-7 spinous processes well developed for each row, and 2-3 obsolete ones near the notch. Two rows of spinous processes are on the two sides of posterior margin. Surface between the striae rough, with evidence of growth lines but without a well defined sculpture, everywhere perforated by microaesthetes, but not on the spinous processes. The arrangement of the conical spinous processes in the postmucronal area of the tail valve is less clear, the conical spinous processes seem irregularly arranged, not in radial rows as in head valve (Fig. 9A).

## Articulamentum

Articulamentum strongly developed with apophyses well developed, rounded, connected by a jugal lamina with external slits in intermediate (Fig. 8L) and tail (Fig. 9E) valves. Head valve with a large, elevated apical area, extending obliquely to the articulamentum, traversed by a series of more or less parallel and columnar thickenings branching towards the apex. Intermediate valve with a smaller but similar apical area. Teeth solid, finely striated on the upper side, in the head valve corresponding to the radial rows of spinous processes, except for the two near the posterior margin for each side, slit rays vaguely evidenced, eaves solid, slit formula 8-13 / 1 / 9-12.

## Remarks

This species was already reported from Gaas by Varone (2008) as "*Chiton* sp. 2", an intermediate valve of width 7 mm.

Some intermediate valves (e.g. Figs 8J-L) show some differences compared to the other intermediate valves, and are characterized by a different shape ( $L/W = 0.61$ ), an apex just more evident and greater elevation ( $H/W = 0.48$ ). We consider these valves as valve ii, the first intermediate one, characterized in several chiton species by a different shape, more lengthened and beaked, and for this reason described as a separate intermediate valve by some authors [e.g. Kaas & Van Belle, 1994: 43 for *Ischnochiton* (*Stenosemus*) *perforatus* Kaas, 1990], or highlighted separated from the other intermediate valves in the iconography (e.g. Kaas et al., 2006: figs 147-150).

The arrangement of the conical spinous processes in the postmucronal area of the tail valves is not clear, some valves are slightly eroded and some spinous processes are therefore not visible. Anyway we illustrate a tail valve where these conical spinous processes in the postmucronal area seem irregularly arranged, not in radial striae as in the head valve and lateral areas of intermediate valves (Fig. 9K).

The valves show a certain variability. The number of radial rows of conical spinous processes in lateral areas of intermediate valves is more frequently 2 (Fig. 8M), but some valves show a third row (Fig. 9I). Slit formula 8-13 / 1 / 9-12. We figure head valves both with 8 (Fig. 8A) and 12 slits (Fig. 9H), 13 slits are present in the paratype ZSM Mol 20060779D. Also the height/width ratio is variable, between 0.40 (Fig. 8L) and 0.50 (Fig. 9J).

The "spinous processes" are quite irregular (and that is why we do not call them simply "spines"), without any kind of sculpture and some of them also directed obliquely. The top is rounded and unperforated. Some are broken, and it is possible to see a hole in the center position (Fig. 8T). Also the oval pustules on the central area of intermediate valves are unperforated.

The large and obliquely extended apical area is a really strange character. Some Paleozoic chitons show a large apical area (e.g. species of the genus *Chelodes* Davidson & King, 1874 from the Silurian of Sweden, see Smith, 1960; Cherns, 1988), but the peculiar sculpture present



in the apical area of *Spinochiton vendrascoi* n. sp. (a series of more or less parallel and columnar thickenings branching towards the apex, **Figs 8G-H, 8Q**) is never present. The meaning of this peculiar sculpture is unclear, and needs further study.

## Comparisons

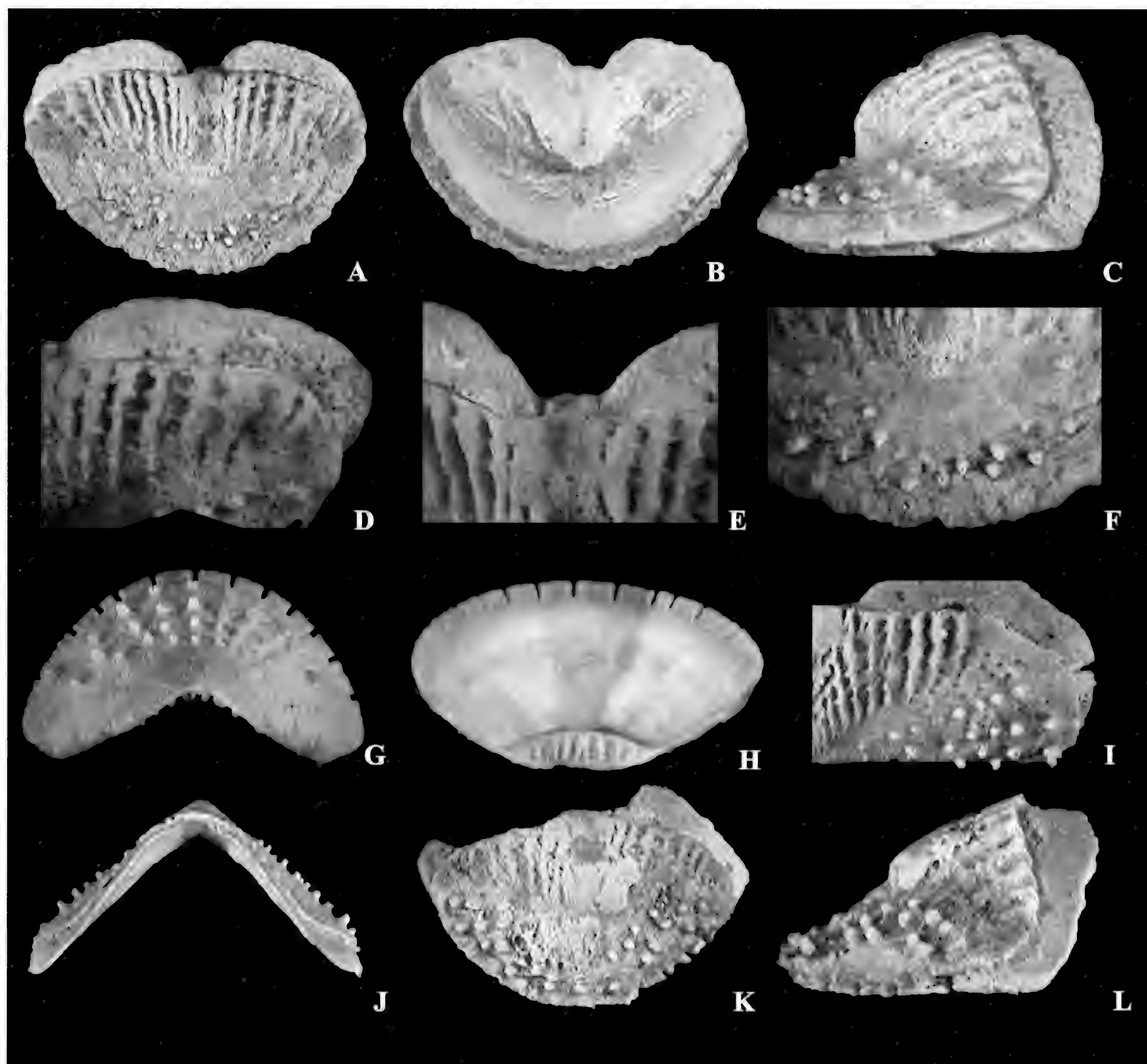
No species of living or fossil chitons show, at our knowledge, the same characters of *Spinochiton gaasi*.

A few species share the head valve character of the apex slightly recurved and front slope strongly concave, e.g. living species of the genus *Nuttallochiton* Plate, 1899 (Kaas & Van Belle, 1987), and the fossil *Oochiton halli* Ashby, 1929 from the Miocene of Balcombe Bay, Victo-

ria, Australia (Ashby, 1929; Smith, 1960), inserted in the Superfamily Chitonoidea Rafinesque, 1815 - Family Loricidae Iredale & Hull, 1923 (Sirenko, 2006). Also the large apical area extending obliquely to the articulation is not a character present in chitons from Tertiary, where the apical area is normally little evident in head valve, and more pronounced but always narrow in intermediate ones.

## Distribution

**Middle Oligocene:** northeastern Atlantic (Rupelian): Aquitaine Basin, France (Cherns & Schwabe, 2017; this paper).



**Fig. 9. A-L.** *Spinochiton gaasi* (Cherns & Schwabe, 2017), Gaas (Larrat), France, Aquitaine Basin, Oligocene (Rupelian). **A-F.** MHNbX 2017.11.1, tail valve (ex JCV), width 5.3 mm. **A-C.** Dorsal, ventral and lateral views. **D, F.** Details of the sculpture. **E.** Details of the jugal lamina connecting the apophyses. **G-H.** Head valve, width 3.5 mm, dorsal and ventral views (JCV). **I.** Intermediate valve, width 6.6 mm, dorsal view (JCV). **J.** Intermediate valve, width 7.2 mm, frontal view (JCV). **K-L.** Tail valve, width 5.3 mm, dorsal and lateral views (JCV).

**Fig. 9. A-L.** *Spinochiton gaasi* (Cherns & Schwabe, 2017), Gaas (Larrat), Francia, Bacino Aquitaniano, Oligocene (Rupeliano). **A-F.** MHNbX 2017.11.1, piastra posteriore (ex JCV), larghezza 5,3 mm. **A-C.** Viste dorsale, ventrale e laterale. **D, F.** Dettaglio della scultura. **E.** Dettaglio della lamina jugale che collega le apofisi. **G-H.** Piastra anteriore, larghezza 3,5 mm, viste dorsale e ventrale (JCV). **I.** Piastra intermedia, larghezza 6,6 mm, vista dorsale (JCV). **J.** Piastra intermedia, larghezza 7,2 mm, vista frontale (JCV). **K-L.** Piastra posteriore, larghezza 5,3 mm, viste dorsale e laterale (JCV).



Superfamily Schizochitonoidea Dall, 1889

Family Schizochitonidae Dall, 1889

Genus *Schizochiton* Gray, 1847

## Type species

*Chiton incisus* Sowerby, 1841, by monotypy.

## Distribution

The genus is known from the Paleocene to the Recent. Four species are known from the Paleogene of Europe [*Schizochiton baylei* (Briart & Cornet, 1887) from the Paleocene of Belgium and Ukraine, three species from the Eocene of Ukraine, *S. parvus* Bielokrys, 1999, *S. carinatus* Bielokrys, 1999, and *S. hirtus* Bielokrys, 1999], and two from the Miocene of W. Pacific Islands (*S. incisus goikulensis* Ladd, 1966 and *S. marshallensis* Ladd, 1966). Only two living species are known, *Schizochiton incisus* (Sowerby, 1841) from the Red Sea up to Philippines and Indonesia, and *S. jousseaumei* Dupuis, 1917 from the Gulf of Aden.

*Schizochiton tasteti* n. sp.  
(Figs 7M-U)

## Type material

Holotype: MHNbX 2017.7.4, an head valve (ex AC), width 2.3 mm (Figs 7M-P). Paratype: MHNbX 2017.7.5, an intermediate valve (ex AC), width 4.4 mm (Figs 7Q-T).

## Type locality

Gaas (Lagouarde).

## Type stage

Oligocene (Rupelian).

## Etymology

In honour of Mr Claude Tastet, who gave permission to dig and research on his property of Larrat.

## Other material

**Oligocene, Rupelian:** Gaas (Lagouarde): 2 head valves, maximum width 5.2 mm (AC).

## Description

Head valve semi-oval, front slope slightly convex, apex small and distinct, tegmentum sculptured with six raised rows of large pustules growing outward toward the anterior margin, with deep holes on the top of each pustule, interspaces between pustule rows with many large and well separated oval granules, smaller near the apex and growing outward the anterior margin.

Intermediate valves elongate, about as long as wide, more or less carinated, anterior margin straight in the

central part, almost straight and strongly slanting at the pleurae, side margins short, posterior margin straight at both sides of the moderately produced, bluntly pointed apex, lateral areas small, hardly or not raised, defined by an elevated diagonal row of large pustules with deep holes on the top, and a more obsolete second radial row of pustules at the posterior margin, tegmentum otherwise sculptured with large oval granules, well separated in the lateral areas and near the diagonal rows of pustules in pleural areas, becoming united and forming short segments, acquiring vaguely zig-zag pattern near the jugal area. Jugal area triangular, longitudinally finely striated, without any other sculpture.

Tail valve not known.

Articulamentum with subrectangular apophyses, insertion plates long, slit formula 6 / 1 / ?, slits shallow, corresponding to tegmental rows of pustules, slit rays indicated, teeth sharp, finely striated on the upper side.

## Remarks

One of the main characters of the genus *Schizochiton* is the deep V-shaped caudal sinus in the tail valve (Kaas et al., 2006, p. 49), unfortunately not comparable in our specimens because we did not find tail valves. However the other characters are sufficient to attribute the valves examined to the genus *Schizochiton*.

The valves are in some cases eroded, so not all characteristics are fully visible. The larger head valve (width 5.2 mm, Fig. 7E) is more eroded, and shows a front slope a bit more convex than the holotype.

The holes on the top of large pustules can be interpreted as the seat of the shell eyes (ocelli) present in living species of *Schizochiton*. The ocelli are evidentially rather fragile to preservation and, at our knowledge, are not preserved in fossil species of *Schizochiton*, as in our specimens. The holes seem deep, penetrating inside the valves.

## Comparisons

Bielokrys (1999) described three species of *Schizochiton* from the Eocene of Ukraine: *S. parvus*, *S. carinatus* and *S. hirtus*. *Schizochiton parvus* and *S. hirtus* are known for a single tail valve, are of smaller size than *S. tasteti* n. sp. (width 0.78 mm for *S. parvus*, 1.40 mm for *S. hirtus*), and have a different sculpture (*S. parvus* smooth and *S. hirtus* a sinuous ornament). *S. carinatus* differs from *S. tasteti* n. sp. by the different sculpture (rounded radial ribs in the head valve and lateral areas and triangular longitudinal ribs in pleural area) and the narrow apophyses.

*Schizochiton baylei* (Briart & Cornet, 1887) differs from *S. tasteti* n. sp. by different sculpture, the different shape of intermediate valve (width more than two times the length) and the different geographic and stratigraphic range (Paleocene of Belgium and Ukraine vs. Oligocene of France).

## Distribution

**Middle Oligocene:** northeastern Atlantic (Rupelian): Aquitaine Basin, France (this paper).



Discussion

This paper greatly extends the knowledge of Oligocene to Miocene chitons from Aquitaine and Ligerian Basins, after the works of Rolle (1862), Benoist (1882), de Rochebrune (1882), Cossmann & Peyrot (1917), Vergneau (1966), Dell’Angelo & Palazzi (1989), Varone (2008), Ca-

huzac et al. (2012), and Cherns & Schwabe (2017). The studied chitons from the localities of Aquitaine and Ligerian Basins, represented by 367 valves, include 19 species in this first part, 13 of which are already known, and six are described as new (Table 1). Spinochitonidae new fam. and *Spinochiton* new gen. are described. Taxa discussed here pertain to species only known in

species	AQUITAINE BASIN							LIGERIAN BASIN	
	OLIGOCENE		MIOCENE				tot.	MIOCENE	tot.
	Rupelian	Chattian	Aquitanian	Burdigal.	Langhian	Serraval.		Late	
<i>Lepidopleurus cajetanus</i>				1	1		2	20	20
<i>Lepidopleurus benoisti</i>		15	1	75	1	1	93		
<i>Leptochiton poirieri</i>	11						11		
<i>Leptochiton</i> cf. <i>L. josei</i>				1			1		
<i>Leptochiton aturriensis</i> n. sp.		22					22		
<i>Parachiton statianus</i>								1	1
<i>Parachiton palmorum</i> n. sp.				2			2		
<i>Hanleya glimmerodensis</i>	7						7		
<i>Ischnochiton rissoi</i>				89		1	90		
<i>Ischnochiton korytnicensis</i>				3			3		
<i>Ischnochiton renardi</i> n. sp.								7	7
<i>Ischnochiton abbessi</i>				1			1		
<i>Stenosemus dolii</i>								1	1
<i>Connexochiton vivesi</i> n. sp.				1			1		
<i>Rhyssoplax corallinus</i>		2	3	20		3	28	5	5
<i>Rhyssoplax assurrectum</i>			1	1			2	1	1
<i>Lucilina saubadeae</i> n. sp.	5						5		
<i>Spinochiton gaasi</i>	60						60		
<i>Schizochiton tasteti</i> n. sp.	4						4		
total	87	39	5	194	2	5	332	35	35

Tab. 1. Number of valves found by Aquitaine and Ligerian Basins and stratigraphy.

Tab. 1. Numero delle piastre trovate nei bacini Aquitaniano e Ligeriano e la stratigrafia.

PALAEOGEOGRAPHICAL DISTRIBUTION					species	GEOCHRONOLOGICAL DISTRIBUTION									
						OLIGOCENE			MIOCENE			PLIOC.	PLEIST.	RECENT	
						early	middle	late	early	middle	late			Atl.	Medit.
●	●	●		●	<i>Lepidopleurus cajetanus</i>										
●		●		●	<i>Lepidopleurus benoisti</i>										
●			●		<i>Leptochiton poirieri</i>										
●					<i>Leptochiton</i> cf. <i>L. josei</i>										
●					<i>Leptochiton aturriensis</i> n. sp.										
	●	●			<i>Parachiton statianus</i>										
●					<i>Parachiton palmorum</i> n. sp.										
●			●		<i>Hanleya glimmerodensis</i>										
●		●		●	<i>Ischnochiton rissoi</i>										
●		●		●	<i>Ischnochiton korytnicensis</i>										
	●				<i>Ischnochiton renardi</i> n. sp.										
●					<i>Ischnochiton abbessi</i>										
	●	●			<i>Stenosemus dolii</i>										
●					<i>Connexochiton vivesi</i> n. sp.										
●	●	●		●	<i>Rhyssoplax corallinus</i>										
●	●				<i>Rhyssoplax assurrectum</i>										
●					<i>Lucilina saubadeae</i> n. sp.										
●					<i>Spinochiton gaasi</i>										
●					<i>Schizochiton tasteti</i> n. sp.										

Tab. 2. Palaeogeographical and geochronological distribution of the species from Aquitaine and Ligerian Basins discussed in this paper, and their post-Miocene presence. (AB = Aquitaine Basin; LB = Ligerian Basin; NI = Northern Italy; NSB = North Sea Basin; PR = Paratethys).

Tab. 2. Distribuzione paleogeografica e geocronologica delle specie provenienti dai bacini dell’Aquitano e del Ligeriano e discusse in questo lavoro e la loro presenza nel post-Miocene. (AB = Bacino Acquitano; LB = Bacino Ligeriano; NI = Nord Italia; NSB = Bacino del Mar del Nord; PR = Paratetide).



Oligocene to Quaternary deposits of Europe (Table 2). Regarding the stratigraphic distribution of the 19 taxa identified by us, 16 have been found in the Aquitaine Basin, six in the Ligerian Basin, and only three species are present in both Basins (*Lepidopleurus cajetanus*, *Chiton corallinus* and *Chiton assurrectum*). Four species are still extant, one in the Mediterranean (*Stenosemus dolii*) and three in both Atlantic and Mediterranean (*Lepidopleurus cajetanus*, *Ischnochiton rissoi* and *Rhyssoplax corallinus*).

Ten species were previously known for the Aquitaine Basin: three described by Rolle, 1862 (*Chiton oligocaenus*, *C. reussi*, *C. modestus*), five by de Rochebrune, 1882 (*Acanthochites dulignonii*, *Gymnoplax benoisti*, *Tonicia gaasensis*, *T. waltebledi*, *Lepidopleurus daubrei*), *Chiton miocenicus* Michelotti, 1847 and *C. leognanensis* Cossmann & Peyrot, 1917. Only two of these pertain to the families treated herein, *Gymnoplax benoisti* (now *Lepidopleurus benoisti*) and *Chiton miocenicus*, but the latter was not present in the studied material (also we note the report of *C. miocenicus* by Cossmann & Peyrot, 1917, is not correct, see above under *Lepidopleurus benoisti*).

A full discussion on the chiton fauna from the Oligocene to Miocene of Aquitaine and Ligerian Basins will be given in a second, forthcoming part of this work.

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# The marine molluscan taxa of Antonino Bivona e Bernardi and of his son Andrea Bivona

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## Abstract

The malacological authors 'Bivona, Ant. in Bivona, And., 1838' appeared to be Antonino Bivona e Bernardi (1778-1837) and his son Andrea Bivona. Thus, father and son had different surnames. A survey is given of all malacological publications of these two authors. Antonino Bivona e Bernardi published three new genera and 25 new species of marine molluscs. He also was reported five times as author of new species in a book by Philippi (1836). Andrea Bivona published two new genera and 28 new species of marine mollusca. A part is derived from a manuscript of his father, a part is added by himself. Andrea Bivona published also 11 new species of terrestrial or fresh water molluscs.

A remarkable and confusing habit of both authors is occasionally to place earlier published species by other authors in synonymy with their newly described species when this species is placed into a newly established genus or transferred to another genus. Publications in journals, not without typographical errors, are sometimes followed by separate reprints with modified texts and plates which are added or removed.

The 63 taxa (including 5 genera) from Bivona e Bernardi and Bivona are listed and for each taxon the more relevant opinions of later authors on the validity and conspecificity is reported, including the opinions expressed in WoRMS. Of the 63 taxa 28 have 'Bivona e Bernardi, 1832', 2 have 'Bivona e Bernardi in Philippi, 1836', 20 have 'Bivona e Bernardi in Bivona, 1838' and 10 have 'Bivona, 1838 or 1839' as author. Thus, of three species Philippi is considered the only author. Of the 60 taxa with father or son as author(s), only 13 appeared presently to be considered valid. And two taxa were never referred to after their publication as a new species.

So far, types of only one marine species have been located and reported in the literature. At least seven eponyms with the epithet 'bivonae' or 'bivoniana' are known. Finally, difficulties with the names of some malacological authors using a noble title and/or a civil name are briefly discussed.

## Keywords

Antonino Bivona e Bernardi, Andrea Bivona, biography, bibliography, history of malacology.

## Riassunto

Gli autori malacologici "Bivona, Ant. in Bivona, And., 1838" sembrano essere Antonino Bivona e Bernardi (1778-1837) e suo figlio Andrea Bivona. Pertanto, padre e figlio avevano diversi cognomi. Viene fornita un'indagine su tutte le pubblicazioni malacologiche di questi due autori. Antonino Bivona e Bernardi ha pubblicato tre nuovi generi e 25 nuove specie di molluschi marini. Venne anche riportato cinque volte come autore di nuove specie in un libro di Philippi (1836). Andrea Bivona ha pubblicato due nuovi generi e 28 nuove specie di molluschi marini. Una parte è derivata da un manoscritto di suo padre; una parte è aggiunta da lui stesso. Andrea Bivona ha pubblicato anche 11 nuove specie di molluschi terrestri o d'acqua dolce. Una notevole e poco chiara abitudine di entrambi gli autori è occasionalmente di mettere specie pubblicate in precedenza da altri autori in sinomia con la loro specie appena descritta quando questa specie è collocata in un genere appena stabilito o trasferita in un altro genere. Le pubblicazioni su riviste, non senza errori tipografici, sono talvolta seguite da ristampe separate con testi e tavole modificati, aggiunti o rimossi.

Sono elencati i 63 taxa (compresi 5 generi) di Bivona e Bernardi e Bivona e per ogni taxon sono riportate le opinioni più rilevanti degli autori successivi sulla validità e la conspecificità, incluse le opinioni espresse in WoRMS. Dei 63 taxa 28 hanno "Bivona e Bernardi, 1832", 2 hanno "Bivona e Bernardi in Philippi, 1836", 20 hanno "Bivona e Bernardi in Bivona, 1838" e 10 hanno "Bivona, 1838 o 1839" come autore. Così, di tre specie Philippi è considerato l'unico autore. Dei 60 taxa con padre o figlio come autore/i, solo 13 attualmente sono sembrati da considerare validi. E due taxa non sono mai stati citati dopo la loro pubblicazione come specie nuove.

Finora sono stati individuati e riportati in letteratura tipi di una sola specie marina. Sono noti almeno sette eponimi con l'appellativo "bivonae" o "bivoniana". Infine, vengono brevemente discusse le difficoltà con i nomi di alcuni autori malacologici che usano un titolo nobiliare e/o un nome civile.

## Parole chiave

Antonino Bivona e Bernardi, Andrea Bivona, biografia, bibliografia, storia della malacologia.

## Introduction

Many years ago, when I noticed the malacological authors 'Bivona, Ant. in Bivona, And., 1838', I was in-

stantly intrigued by the background of these authors. Recently, websites like the Biodiversity Heritage Library, Internet Archive and Google Books, have made it relatively easy to consult the original literature. It appe-



ars that the son had published posthumously a manuscript of his father.

However, first of all the correct names of the authors have to be determined. Surfing the internet resulted in many different names for the father, i.e. the first names Antonio, Antonino, Antonini, and the surnames Bivona, Bivona Bernardi, Bivona-Bernardi, Bivona e Bernardi, de Bivona Bernardi, Bivona (Bernardo) and even Bernardi Bivona. Priolo (1948: p. 6-8) already utilized different surnames, 'Bivona Bernardi' for the father and 'Bivona' for the son. Welter-Schultes & Audibert (2013: p. 10) noticed the problem concerning these malacological authors. They concluded correctly that Antonino Bivona Bernardi and Andrea Bivona were different persons. However, their solution is not completely perfect, as the son explicitly stated that the surname of his father should be Bivona e Bernardi (Bivona, 1838a & 1838b). The father, born at Messina on 24 October 1778, as the son of Andrea Bernardi and Maddalena Chiocciola, lost his parents as a child and was adopted by Baron Antonino Bivona (Brancato, 1968). Antonino Bivona e Bernardi (Fig. 1) became a famous botanist (e.g. Parlato, 1837; Bivona, 1837; Raimondo & Not, 1987; Anonymous, 1990; Ottaviani, 2004), and died of cholera at Palermo on 7 July 1837 (Di Granatelli, 1838). In all his malacological publications (see references) the son called himself invariably (Andrea) Bivona. Apparently, surnames were not fixed at that period. Perhaps the occupa-



**Fig. 1.** Antonino Bivona e Bernardi (1778-1837) [derived from website of Università degli Studi di Palermo].

**Fig. 1.** Antonino Bivona e Bernardi (1778-1837) [tratto dal sito web dell'Università degli Studi di Palermo].

tion of Sicily by British forces from 1806 to 1815, thus preventing the Code Napoleon to become effective, was important in this respect.

During his life, Antonino Bivona e Bernardi was well known by other naturalists and malacologists. In 1810 Rafinesque Schmalz dedicated his book on new genera and species of animals and plants of Sicily to D. Antonino Bivona Bernardi, barone di Alta Torre [=Baron of the High Tower]. Several years later he described the intrigue around the vacancy of the chair of Botany at the University of which Bivona [=Bivona e Bernardi] or he were the victim in favor of the son - not a botanical author - of the deceased professor Tineo (Rafinesque Schmalz, 1836: p. 42). Antonino Bivona e Bernardi also met in Sicily William Swainson, naturalist and author of several malacological books (Lentini, 2012). In an "Elogio storico" [=historical eulogy] the son published letters to his father from, amongst others, malacological authors as Poli, Rüppell, Férussac, Blainville, Delle Chiaje and Maravigna (Bivona, 1840a).

## Malacological publications

Antonino Bivona e Bernardi published seven small articles consecutively in which three new genera and 25 new species were described (Bivona e Bernardi, 1832a-g). One of these seven articles concerns not Mollusca but barnacles (Bivona e Bernardi, 1832f). Drawings of nine species are supposed to be present in plate 3. However, the drawings in plate 3 do not refer to molluscs. It is unknown why the correct plate 3 is missing. Philippi (1836 & 1844) reported respectively five and four new species with Bivona [=Bivona e Bernardi] as author. The authorship of these species is also discussed below.

Andrea Bivona published two new genera and 28 new species. A part is derived from a manuscript of his father, a part is added by himself (Bivona, 1838a-c & 1839b, d). The correct author of these new taxa is discussed below. To the separate reprint of the original article (Bivona, 1838a) one plate is added, and the article is split into two parts (Bivona, 1838b & 1838c). The text of the reprint is modified in several parts from the original article and in the text of the reprint (and, of course, in the original article without a plate) references to the corresponding figures in the plate are missing. There is just a plate with figures and numbers. There are 26 new species and 24 figures. But, in some cases the drawing is certainly nonspecific with the species suggested by its sequence in the text. See list below for comments. A further two new fossil marine species were described by Bivona (1839b, 1839d). The publications on land and/or fresh water species from Bivona (1839a-c, 1839e, 1840b) with 11 new species are not discussed here.

In the publications of both father and son, and other Italian authors in the 19th century, the binomial Italian name comes first, followed by the binomial Latin name between brackets. More peculiar is the habit of placing previously established nominal taxa into synonymy with their newly described species (sometimes indicated by Nobis or N.). Especially, when this new species is



placed into a newly established genus or transferred to another genus different from the genus in which the original author has placed his species. These newly described species by Bivona e Bernardi or Bivona might be designated as subjective junior synonyms. But, other malacologists have the freedom to decide that this subjective junior synonym should be a valid species.

### Alphabetical list of the marine malacological taxa (original combinations of species, genus) of Antonino Bivona e Bernardi and Andrea Bivona

It is only intended to report for each taxon the more relevant opinions of later authors on the validity and conspecificity of this taxon, including the opinions expressed in WoRMS (www.marinespecies.org, consulted on 10 August 2017). It is not intended to fully interpret the Latin and Sicilian/Italian descriptions and the figures in the plates. Of the three plates in Bivona e Bernardi (1832a-g) only the first two have been published and are of reasonable quality. The third one has no pictures of shells at all. It is not clear what has gone wrong. And the plate in Bivona (1838b) is, at least in the only copy I was able to obtain, of poor quality.

In the following list, fossil materials are specifically indicated, while the remaining is Recent and all are coming from Palermo and other Sicilian localities

**angustata, Bullaea** Philippi, 1836 (p. 121, pl. VII, fig. 17). Source described as “Bivon. coll.” [=Bivona collection]. Thus, following Verduin (1983) Philippi is the author. In WoRMS - *Bulleaea angustata* Philippi, 1836 - is listed as a synonym of *Philine catena* (Montagu, 1803). Coan & Kabat (2017b: p. 201) incorrectly report “ex Bivona ms”.

**auriscalpium, Loxostoma** Bivona e Bernardi in Bivona, 1838 (1838a: p. 222 & 1838b: p. 6, fig. 6?). Three species, *Tubo* [sic] *auriscalpium* Gmelin, *Turbo acicula* Delle Chiaje and *Rissoa acicula* Risso, are placed into synonymy with the new species. Not listed in WoRMS. *Luxostoma* in 1838a is a misspelling, changed to *Loxostoma* in 1838b. It is very likely that the present species is a junior synonym and a secondary homonym of *Rissoa auriscalpium* (Linnaeus, 1758).

**bidentata, Ovatella** Bivona e Bernardi, 1832 (1832g: p. 18, pl. 2, fig. 10). Philippi (1844: p. 118) has synonymised this taxon with *Auricula bivonae* Philippi, 1844 (*nomen novum*), which is according to WoRMS a synonym of *Auriculinella bidentata* (Montagu, 1808). According to Coan & Kabat (2017b: p. 207) the author of *Auricula bivonae* should be Küster ex Philippi ms, 1841.

**cancellata, Loxostoma** Bivona e Bernardi in Bivona, 1838 (1838a: p. 220 & 1838b: p. 3, fig. 1?). Seven species such as *Turbo cimex* Gmelin and *Alvania mammillata* Risso are placed in synonymy with the new species. Not listed in WoRMS. According to Aradas (1848: p. 75) *Loxostoma cancellata* is a synonym of *Rissoa calathiscus* of Laskey (= *Turbo calathiscus* Montagu; Laskey, 1811: p. 406) and the latter is according to WoRMS a dubious synonym of *Alvania cimex* (Linnaeus, 1758).

**cancellatus, Fusus** Bivona e Bernardi in Bivona, 1838 (1838a: p. 320 & 1838b: p. 14, fig. 21?). Fossil and Recent. In 1838a reported as “aggiunta ai fusi” [=added to *Fusus*], not in 1838b. This alteration in authorship is considered as a correction by the author. According to WoRMS it is a synonym of *Trophonopsis muricata* (Montagu, 1803). Two junior homonyms are reported by Snyder (2003: p. 60).

**candida, Marginella** Bivona e Bernardi, 1832 (1832g: p. 19, pl. 3, fig. 4A-B; pl. 3 without pictures of shells). Listed in WoRMS as a synonym of *Ringicula auriculata* (Ménard de la Groye, 1811), Ciccone & Savona (1982: p. 20) have the same opinion.

**carinata, Pleurotoma** Bivona, 1838 (1838a: p. 226 & 1838b: p. 12, fig. 17?). No information whether fossil or Recent. Reported as “aggiunte alle pleurotome” [=added to *Pleurotoma*]. It is a junior homonym of *Pleurotoma carinata* Deshayes, 1834, and *P. carinata* Gray, 1834 (Tucker, 2004: p. 179-180). Listed in WoRMS as a synonym of *Spirotropis carinata* (Bivona, 1838), fossil. According to Janssen (1993: 253) it is a *nomen dubium*.

**carinatus, Murex** Bivona e Bernardi, 1832 (1832g: p. 23, pl. 3, fig. 12; pl. 3 without pictures of shells). Fossil near Palermo. Not listed in WoRMS. It is a junior homonym of *Murex carinatus* Pennant, 1777, and according to Aradas & Benoit (1876: p. 263) it is conspecific with *Murex vaginatus* Jan [= *Pagodula vaginata* (de Cristofori & Jan, 1832)].

**carnea, Tornatella** Bivona e Bernardi, 1832 (1832g: p. 17, pl. 2, fig. 9). Not listed in WoRMS. According to Aradas & Benoit (1874: p. 142) it is a synonym of *Acteon tornatilis* Linnaeus, 1758.

**cincta, Pleurotoma** Bivona, 1838 (1838a: p. 226 & 1838b: p. 12, fig. 18?). Fossil near Palermo. Reported as “aggiunte alle pleurotome” [=added to *Pleurotoma*]. Not listed in WoRMS. Junior homonym of *Pleurotoma cincta* of three authors, i.e. Lamarck, 1822, Sowerby, 1834 and Deshayes, 1834 (Tucker, 2004: p. 202). Aradas (1848: p. 76) considers this species to be conspecific with *Pleurotoma elegans* Scacchi, and the latter is according to WoRMS a synonym of *Crassopleura maravignae* (Bivona Ant. in Bivona And., 1838). However, as Bivona (1838a: p. 227) mentioned a length of *Pleurotoma cincta* of approximately 23 mm (lunghezza 13 linee) and Poppe & Goto (1991: p. 166) report 15 mm as the maximum length of *Crassopleura maravignae*, this synonymy is doubtful.

**Cumia** Bivona, 1838 (1838a: p. 322 & 1838b: p. 16). Description in 1838b is incomplete, probably complete in Bivona (1838c). Andrea Bivona (1838a: p. 323) has stated explicitly - Io stabilisco il genere *Cumia* - to be the author of this genus. Accepted In WoRMS as *Cumia* Bivona-Bernardi, 1838.

**decussata, Cumia** Bivona e Bernardi in Bivona, 1838 (1838a: p. 322; not in 1838b, probably in 1838c). When describing this species Andrea Bivona (1838a: p. 324) explicitly refers to a manuscript of his father. *Murex maculosum* Gmelin, the original name of the Indo-Pacific mollusc *Colubraria maculosum* (Gmelin, 1791) has been



placed in synonymy with the new species. In WoRMS listed as a synonym of *Cumia reticulata* (Blainville, 1829). *denticulus*, *Loxostoma* Bivona e Bernardi in Bivona, 1838 (1838a: p. 221 & 1838b: p. 5, fig. 4?). In WoRMS listed as a synonym of *Rissoa monodonta* Philippi, 1836; see *monodonta*.

*depressa*, *Hyalaea* Bivona e Bernardi, 1832 (1832b: p. 57, pl. 1, figs. 4-5). Fossil near Palermo. In WoRMS listed as a synonym of *Diacria trispinosa* (Blainville, 1821).

*digitata*, *Tubolana* Bivona e Bernardi, 1832 (1832a: p. 56, pl. 1, figs. 1-3). Fossil near Palermo. According to Aradas & Calcara (1843: p. 220) a synonym of *Clavagella bacillaris* Deshayes. Not listed in WoRMS. Low & Tan (2011) mention *Tubolana ditata* as a spelling of *Tubolana digitata*. However, the former is the Italian name, the latter is the latinized name. *Tubulana* on p. 56 is a misspelling. The name *Tubolana* has been suppressed (ICZN Opinion 2325, 2013).

*eburnea*, *Pleurotoma* Bivona e Bernardi in Bivona, 1838 (1838a: p. 224 & 1838b: p. 9, fig. 12?) *Pleutoma* on p. 224 is a misspelling, corrected in Bivona (1838b). Listed in WoRMS as a synonym of *Mangelia taeniata* (Deshayes, 1835).

*effossa*, *Venus* Bivona e Bernardi in Philippi, 1836 (1836: p. 43, pl. III, fig. 20). Source described as “Bivon. mscr.” [=Bivona manuscript]. In WoRMS listed as *Globivenus effossa* (Philippi, 1836).

*fasciculata*, *Vermetus triqueter* var. Philippi, 1836 (1836: p. 172). Source described as “Bivon.; fossil” [=Bivona fossil]. Bieler & Petit (2011: 36) consider this correctly a *nomen nudum*. *Vermetus triqueter* is an incorrect subsequent spelling of *V. triquetrus* Bivona e Bernardi, 1832 by Philippi (1836: p. 170) (Bieler & Petit, 2011: p. 65). Not listed any more in the second edition of Philippi (1844).

*galli*, *Pleurotoma* Bivona, 1838 (1838a: p. 226 & 1838b: p. 11, fig. 16?). Reported as “aggiunte alle pleurotome” [=added to *Pleurotoma*]. Listed in WoRMS as a synonym of *Mangelia unifasciata* (Deshayes, 1835).

*gigas*, *Vermetus* Bivona e Bernardi, 1832 (1832d: p. 5, pl. 2, figs. 1-2). Listed in WoRMS as a synonym of *Thylacodes arenarius* (Linnaeus, 1758).

*glomeratus*, *Vermetus* Bivona e Bernardi, 1832 (1832d: p. 7, pl. 2, fig. 5). Type species of *Bivonia* Gray, 1847 (Bieler & Petit, 2011: p. 39). Monterosato (1884: p. 81) considered the original combination preoccupied by *Serpula glomerata* Linnaeus, 1758, and renamed it *Bivonia petraea*. In WoRMS listed as a synonym of *Dendropoma cristatum* (Biondi, 1859) and as secondary homonym.

*intermedia*, *Pleurotoma* Bivona e Bernardi in Bivona, 1838 (1838a: p. 225 & 1838b: p. 10, fig. 14?). *Mangelia striolata* Risso has been placed in synonymy with the new species. *Pleurotoma* on p. 225 is a misspelling, corrected in Bivona (1838b). Junior homonym of *Pleurotoma intermedia* Bronn, 1832 (Tucker, 2004: p. 500-501). Not listed in WoRMS.

*juvenis*, *Fusus* Bivona, 1838 (1838a: 319 & 1838b: p. 15, fig. 23?). Published as “aggiunta ai fusi” [=added to *Fusus*]. In WoRMS listed as *nomen dubium*. According to Snyder (2003: p. 120) *Fusus juvenis* Bivona, 1838 is a valid species.

*laevigata*, *Pisania* Bivona e Bernardi, 1832 (1832e: p. 12, pl. 2, fig. 7). *Mitrella flaminea*, *Purpura corniculata* and *Fusus glaber*, all three Risso, 1826, have been placed in synonymy with the new species. All four species are listed in WoRMS listed as synonym of *Mitrella scripta* (Linnaeus, 1758).

*Loxostoma* Bivona e Bernardi in Bivona, 1838 (1838a: p. 218 & 1838b: p. 2). In WoRMS listed as a synonym of *Rissoa* Desmarest, 1814.

*maravignae*, *Pleurotoma* Bivona, 1838 (1838a: p. 319 & 1838b: p. 13, fig. 19?). Fossil near Monte Pellegrino (Palermo). Reported as “aggiunte alle pleurotome” (=added to *Pleurotoma*). In WoRMS listed as the original combination of *Crassopleura maravignae* (Bivona Ant. in Bivona And., 1838), type species of *Crassopleura* Monterosato, 1884. Van Aartsen (1996), when discussing the synonymy of *Crassopleura maravignae* (Bivona, 1838), considers this species to be Recent, without referring to its fossil origin.

*marginata*, *Volvaria* Bivona e Bernardi, 1832 (1832g: p. 19, pl. 3, figs. 5 A-B; pl. 3 without pictures of shells). In WoRMS listed as the original combination of *Granulina marginata* (Bivona, 1832).

*monodonta*, *Rissoa* Philippi, 1836 (p. 151, pl. X, fig. 9). Source described as “Bivon. coll.” [=Bivona collection]. Thus, following Verduin (1983) Philippi is the author. Accepted in WoRMS. Coan & Kabat (2017b: p. 164) incorrectly describe the source as “ex Bivona ms”.

*niveum*, *Cerithium* Bivona e Bernardi in Bivona, 1838 (1838a: p. 321 & 1838b: p. 15, **not** fig. 24!). Listed in WoRMS as a synonym of *Bittium lacteum* (Philippi, 1836).

*nodulosa*, *Pisania* Bivona e Bernardi, 1832 (1832e: p. 13, pl. 2, figs. 8 A-B & 1832g: p. 24, additional text). *Purpura rustica* Lamarck and *Mitrella marminia* Risso were placed in synonymy. In WoRMS listed as the original combination of *Aplus nodulosus* (Bivona Ant., 1832). *Mitrella marminea* [sic] Risso, 1826 is in WoRMS a dubious synonym of *Aplus scaber* (Locard, 1892) and of *Aplus dorbignyi* (Payraudeau, 1826).

*Ovatella* Bivona e Bernardi, 1832 (1832c: p. 58. Accepted in WoRMS as *Ovatella* Bivona-Bernardi, 1832. Type species by subsequent designation (Monterosato, 1906: p. 126) is *Ovatella punctata*, Bivona, in WoRMS a synonym of *Ovatella firminii* (Payraudeau, 1827 [sic]).

*panormitana*, *Cyrena* Bivona, 1839 (1839d: p. 21; 1893b: p. 21, figs 11a-b). Fossil from surroundings of Palermo. Listed in WoRMS as a synonym of *Spisula solida* (Linnaeus, 1758).

*panormitana*, *Hipponix* Bivona, 1839 (1839d: p. 22). Fossil from surroundings of Palermo. Not listed in WoRMS. *Hiponix* Defrance on p. 22 is a misspelling of *Hipponix* Defrance, 1819.

*Pisania* Bivona e Bernardi, 1832 (1832e: p. 8). In WoRMS accepted as *Pisania* Bivona-Bernardi, 1832. In Opinion 740 of the ICZN the genus name has been placed on the Official List of Generic Names in Zoology with as type species *Pisania striatula* Bivona, 1832 (China, 1965).

*planicosta*, *Scalaria* Bivona e Bernardi, 1832 (1832g: p. 16, pl. 2, fig. 13). In WoRMS listed as a synonym of *Epi-*



*tonium turtonis* (Turton, 1819). The figure shows very probably incorrectly a sinistral shell, just like the figured incorrect sinistral shell of *Scalaria pulchella*.

**pliciferus**, *Murex* Bivona e Bernardi, 1832 (1832g: p. 22, pl. 3, fig. 10; pl. 3 without pictures of shells). In WoRMS listed as a synonym of *Muricopsis cristata* (Brocchi, 1814).

**polita**, *Ovatella* Bivona e Bernardi, 1832 (1832c: p. 59, pl. 1, fig. 7). Listed in WoRMS as a synonym of *Megastomia conoidea* (Brocchi, 1814). Van Aartsen (1987: p. 11, fig. 34) selected - and figured - the lectotype of *Ovatella polita* (Bivona, 1832) out of six syntypes found in the Coen-collection (Coen 3725) present in the Hebrew University of Jerusalem (HUJ MOL 20845). This type material has probably via the collections of subsequently Brugnone and Monterosato ended up in the collection of Coen (Mienis, personal communications, November 2017 & January 2018).

**politum**, *Buccinum* Bivona e Bernardi, 1832 (1832g: p. 21, pl. 3, figs. 8 A-B; pl. 3 without pictures of shells). *Planaxis olivacea* Risso [= *Tritia corniculum* (Olivier, 1792)] was placed in synonymy with the new species and listed in WoRMS accordingly.

**propinqua**, *Pleurotoma* Bivona e Bernardi in Bivona, 1838 (1838a: p. 223 & 1838b: p. 8, fig. 9?). Junior homonym of *Pleurotoma propinqua* Deshayes, 1834 (Tucker, 2004: p. 795). Listed in WoRMS as a synonym of *Comarmondia gracilis* (Montagu, 1803).

**protractum**, *Cerithium* Bivona, 1838 (1838a: p. 321 & 1838b: 15, **not** fig. 25!). Reported as “aggiunta” (=added). Accepted in WoRMS as *Cerithium protractum* Bivona Ant. in Bivona And., 1838.

**pulchella**, *Scalaria* Bivona e Bernardi, 1832 (1832g: p. 17, pl. 3, fig. 2; pl. 3 without pictures of shells; also pl. 2, fig. 14). In WoRMS listed as the original combination of *Epitonium pulchellum* (Bivona, 1832). On pl. 2, fig. 14 ‘*Scalaria bellina*’ is shown, the Italian name for *Scalaria pulchella*. This figure shows very probably incorrectly a sinistral shell, like the incorrectly figured sinistral shell of *Scalaria planicosta*.

**punctata**, *Ovatella* Bivona e Bernardi, 1832 (1832c: 58, pl. 1, fig. 6). Listed in WoRMS as a synonym of *Ovatella firminii* (Payraudeau, 1827 [sic]).

**punctulata**, *Loxostoma* Bivona e Bernardi in Bivona, 1838 (1838a: p. 221 & 1838b: p. 4, fig. 3?). *Rissoa violacea* Risso, *Alvania sulzeriana* Risso and *Turbo rissoanus* Delle Chiaje were placed in synonymy with the new species. Not listed in WoRMS. According to Aradas (1848: p. 75) a synonym of *Rissoa costata* Desmarest In WoRMS both *Turbo rissoanus* and *Rissoa costata* are synonymous with *Rissoa variabilis* (Megerle von Mühlfeld, 1824).

**pusilla**, *Mitra* Bivona e Bernardi, 1832 (1832g: p. 18, pl. 3, fig. 3 & 24, additional text; pl. 3 without pictures of shells). Listed in WoRMS as a dubious synonym of *Pusia tricolor* (Gmelin, 1791).

**scalarinus**, *Murex* Bivona e Bernardi, 1832 (1832g: p. 22, pl. 3, fig. 11; pl. 3 without pictures of shells). *Fusus scalarioides* [sic] Lamarck has been placed in synonymy with a question mark. Listed in WoRMS as a synonym of *Dermomurex scalaroides* (Blainville, 1829).

**semisurrectus**, *Vermetus* Bivona e Bernardi, 1832 (1832d:

p. 5, pl. 2, fig. 3). Type species of *Orthoglyphus* (Bieler & Petit, 2011: p. 58). Listed in WoRMS as *Thylaeodus semisurrectus* (Bivona-Bernardi, 1832).

**similis**, *Pleurotoma* Bivona, 1838 (1838a: p. 225 & 1838b: p. 11, fig. 15?). Reported as “aggiunte alle pleurotome” [=added to *Pleurotoma*]. Listed in WoRMS as *Fusiturris similis* (Bivona Ant. in Bivona And., 1838).

**squamosus**, *Fusus* Bivona e Bernardi in Bivona, 1838 (1838a: p. 32 & 1838b: p. 14, fig. 22?). Reported in 1838a as “aggiunta ai fusi” [=added to *Fusus*], but not in 1838b. This alteration is considered as a correction of the author. In WoRMS listed as *Hirtomurex squamosus* (Bivona Ant. in Bivona And., 1838). In WoRMS *Fusus squamulosus* Philippi, 1836 [non Deshayes, 1834; see Coan & Kabat (2017b: p. 185-186)] is listed as a synonym of *Fusus squamosus*, published two years later.

**stria**, *Buccinum* Bivona e Bernardi, 1832 (1832g: p. 22, pl. 3, fig. 9; pl. 3 without pictures of shells). Fossil near Palermo and Messina. Not listed in WoRMS. Philippi (1836: p. 227) has synonymised this taxon with *Buccinum semistriatum* Brocchi, 1814.

**striarellus**, *Fusus* Bivona e Bernardi in Bivona, 1838 (1838a: p. 225 & 1838b: p. 13, fig. 20?). Fossil near Palermo. Not listed in WoRMS. According to Aradas (1848: p. 76) and Snyder (2003: p. 192) this taxon is a synonym of *Pleurotoma columnae* (Scacchi, 1835).

**striatula**, *Pisania* Bivona e Bernardi, 1832 (1832e: p. 11, pl. 2, figs. 6 A-D). *Voluta syracusana* Gmelin has been placed in synonymy. It is the type species of *Pisania* (China, 1965) and listed in WoRMS as a synonym of *Pisania striata* (Gmelin, 1791).

**subcancellatus**, *Vermetus* Bivona e Bernardi, 1832 (1832d: p. 7). Type species of *Thylacodus* Mörch (Bieler & Petit, 2011: p. 61). Listed in WoRMS as a synonym of *Petalconchus glomeratus* (Linnaeus, 1758).

**subdiaphanum**, *Buccinum* Bivona e Bernardi, 1832 (1832g: p. 20, pl. 3, fig. 6-7; pl. 3 without pictures of shells). *Planaxis lineolata* Risso, 1826 [= *Tritia cuvierii* (Payraudeau, 1826)] has been placed in synonymy with the new species and the latter is listed in WoRMS accordingly.

**subcaudata**, *Pleurotoma* Bivona e Bernardi in Bivona, 1838 (1838a: p. 225 & 1838b: p. 10, fig. 13?). *Pleurotoma* on p. 225 is a misspelling, corrected in Bivona (1838b). Listed in WoRMS as a synonym of *Mangelia multilineolata* (Deshayes, 1835).

**tereticosta**, *Loxostoma* Bivona e Bernardi in Bivona, 1838 (1838a: p. 220 & 1838b: 4, fig. 2?). Published as junior synonym of eight species, for instance *Alvania boria* Risso. Not listed in WoRMS. According to Aradas (1848: p. 75) a synonym of *Rissoa montagui* of Paix. [=Payraudeau]. The latter and *Alvania boria* Risso, 1826 are in WoRMS both listed as a synonym of *Alvania discors* (Allan, 1818).

**testae**, *Pecten* Bivona e Bernardi in Philippi, 1836 (1836: p. 81, pl. 5, fig. 17). Source described as “Bivona mscr” [=Bivona manuscript]. In WoRMS - *Pecten testae* Bivona in Philippi, 1836 - listed as a synonym of *Palliolium incomparabile* (Risso, 1826).

**triquetrus**, *Vermetus* Bivona e Bernardi, 1832 (1832d: p.



6). *Serpula fascicularis* Lamarck (Annelidae) is listed as a possible synonym. Accepted in WoRMS as *Vermetus triquetrus* Bivona-Bernardi, 1832.

***Tubolana*** Bivona e Bernardi, 1832 (1832a: p. 55). Type species by monotypy *Tubolana digitata* Bivona e Bernardi, 1832. Not listed in WoRMS. Recently Low & Tan (2011) requested the suppression of this taxon. Consequently, it has been suppressed (ICZN Opinion 2325, 2013).

***undata*, *Loxostoma*** Bivona e Bernardi in Bivona, 1838 (1838a: p. 222 & 1838b: p. 6, fig. 6?). Not listed in WoRMS. *Luxostoma* on p. 222 is a misspelling, changed to *Loxostoma* in 1838b. According to Aradas (1848: p. 75) a synonym of *Rissoa radiata* Philippi, which is the original name of *Pusillina radiata* (Philippi, 1836) in WoRMS.

***undatiruga*, *Pleurotoma*** Bivona e Bernardi in Bivona, 1838 (1838a: p. 222 & 1838b: p. 7, fig. 7?). Fossil near Taranto. In WoRMS listed as *Fusiturris undatiruga* (Bivona Ant. in Bivona And., 1838), which is the type species of *Fusiturris* Thiele, 1929. According to Tucker (2004: p. 1036) the original spelling *ondatiruga* by Bivona (1838a) is emended to *undatiruga* by Bivona (1838b). Bivona does not mention the earlier spelling of the specific name. But even if the emendation is not justified, the prevailing usage (see the numerous references in Tucker, 2004) of this incorrect subsequent spelling makes it a justified emendation (ICZN, article 33.2.3.1).

***versicolor*, *Pleurotoma*** Bivona e Bernardi in Bivona, 1838 (1838a: p. 224 & 1838b: p. 9, fig. 11?). Published as a possible synonym of *Pleurotoma spinulosa* Risso, 1826. According to Aradas & Benoit (1876: p. 250) a synonym of *Pleurotoma reticulatum* (Brocchi, 1814: Reeve is error). Not listed in WoRMS. Junior homonym of *Pleurotoma versicolor* Scacchi, 1836 (Tucker, 2004: p. 1056).

***virgata*, *Pleurotoma*** Bivona e Bernardi in Bivona, 1838 (1838a: p. 223 & 1838b: p. 7, fig. 8). Fossil near Palermo. Not listed in WoRMS. Tucker (2004: p. 1063) has provided a list of possible synonyms.

***vulpina*, *Pleurotoma*** Bivona e Bernardi in Bivona, 1838 (1838a: p. 223 & 1838b: p. 8, fig. 10?). In WoRMS listed as a synonym of *Mangelia attenuata* (Montagu, 1803).

Of the 63 taxa (including 5 genera) listed above 28 have 'Bivona e Bernardi, 1832', 20 have 'Bivona e Bernardi in Bivona, 1838' and 10 have 'Bivona, 1838 or 1839' as author. Of the five species which Philippi (1836) reported with Bivona [=Bivona e Bernardi] as author, only two are correct in this respect. Of the 60 taxa with father and/or son as author(s), only 13 appeared presently to be valid. This validity can, of course, change. And two taxa - *Loxostoma auriscalpium* Bivona e Bernardi in Bivona, 1838, *Hipponix panormitana* Bivona, 1839 - were never referred to, as least to my knowledge, after their publication as a new species.

## Types

According to Jeannette Power (1839: p. 106) and to Giovanni Power (1842: p. 224) Andrea Bivona had "una estesa collezione di molluschi" [=an extensive collection

of molluscs]. It is highly probable that in this collection the types of both father and son were present. However, Verduin (1983: p. 63) tried in vain to obtain a type from, what he called, the Bivona collection, and received the message from S. di Geronimo (Catania) that he does not believe that the collection of Bivona still exists. But Palazzi (2002) claims that at least parts of the Bivona collection are to be found in several Italian Museum collections (Catania, Milan, Rome). The types of one species, *Ovatella polita* Bivona e Bernardi, 1832 have been located in the Coen-collection, see list above. Other types of Antonino Bivona e Bernardi and Andrea Bivona might be present in this collection too (Mienis, 2012; p. 15). So far, syntypes of the land snail *Helix parlatoris* Bivona, 1839 have been found at the Hebrew University of Jerusalem (HUJ MOL 55002; ex Coen 6246) (Mienis, personal communication, January 2018).

## Eponyms

At least seven eponyms on molluscs with the epithet 'bivonae' or 'bivoniana' were published. In chronological order: *Panopaea bivonae* Philippi, 1836: p. 8, *Atlanta bivonae* Pirajno, 1840b: p. 149, *Pleurotoma bivonae* Maravigna, 1840: p. 326, *Pleurotoma bivonae* Bell. [=Bellardi] in Sismonda, 1842: p. 33 (P. Philippi Bell. Mich., nomen nudum?), *Auricula bivonae* Küster ex Philippi ms, 1841 (Coan & Kabat, 2017b: p. 207), *Pleurotoma bivoniana* Maravigna, 1853: p. 128, *Limax bivonae* Lessona & Pollonera, 1882: p. 26. The epithet 'bivonae' is the genitive of Bivona considered as feminine name.

The genus *Bivonia* has been erected by Gray, 1842 (Bierler & Petit, 2011: p. 13). However, this appeared to be a junior homonym of *Bivonia* Cocco, 1832 (Crustacea).

The species *Atlanta bivonae* has as author Pirajno, and not Mandralisca as in WoRMS. In other publications this author used first of all his 'civil' name Enrico Pirajno, and not his title 'Barone di Mandralisca' (Pirajno, 1840a & 1842). Not every malacologist used only his title like the 'Marchese di Monterosato', whose name is Tommaso di Maria Allery (Coan & Kabat, 2017a) or Tommaso Allery di Maria [http://www.catalogomultimediale.unina.it/, consulted 17 August 2017] or Tommaso Di Maria [http://www.societaitalianadimalacologia.it/, consulted 17 August 2017]. The correct name is Tommaso Di Maria or simply Monterosato as he liked to be called (Giannuzzi Savelli, personal communication, January 2018).

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tonino Bivona e Bernardi and Andrea Bivona in the collection of the Hebrew University of Jerusalem. Finally, I am grateful for the critical comments, suggestions for improvement and relevant additional information from the reviewers Riccardo Giannuzzi Savelli and Danilo Scuderi.

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# Two new species of the Cerithiopsidae (Gastropoda: Triphoroidea) for the Mediterranean Sea

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## Abstract

In this paper, two new Mediterranean species of the family Cerithiopsidae are described; *Dizoniopsis zannii* and *Cerithiopsis carlottae*, both found by examining sediments dredged between 80 and 110 m in the Central and Western Mediterranean. The comparisons with the known species, including those from outside the Mediterranean, allows, us to establish these two new taxa.

## Keywords

Gastropoda, Cerithiopsidae, new species, Mediterranean Sea.

## Riassunto

In questo contributo si descrivono due nuove specie del Mar Mediterraneo appartenenti alla famiglia Cerithiopsidae: *Dizoniopsis zannii* e *Cerithiopsis carlottae*, rinvenute esaminando sedimenti dragati fra 80 e 110 m nel Mediterraneo Centrale e Occidentale. I confronti effettuati con le specie conosciute, sia mediterranee sia extra-mediterranee, ci hanno permesso di stabilire che si tratta di due nuovi taxa.

## Parole chiave

Gastropoda, Cerithiopsidae, nuove specie, Mar Mediterraneo.

## Introduction

Thirty four species of Cerithiopsidae have been recorded from the Mediterranean Sea so far: twenty five belonging to the genus *Cerithiopsis*, four *Dizoniopsis*, two *Kratchia*, one *Krachiopsis*, one *Onchodia* and one *Seila*. Considering the remarkable intraspecific variability of the family, we made accurate comparisons with all known species assisted by SEM photos (Scanning Electron Microscope). Such comparison enabled us to establish them as two new species, *Dizoniopsis zannii* from Torre Zozzoli (Taranto, Italy), and *Cerithiopsis carlottae* from Malaga and Castellammare di Stabia (Napoli, Italy).

Aware of the continuous discovery of alien marine organisms in the Mediterranean we have expanded our research comparing these two species with the extra-Mediterranean ones introduced by natural or anthropic route through Gibraltar and Suez.

We mention some reports of alien species of mollusks: Monterosato (1878), Dautzenberg (1896), Tillier L. & A. Bavay (1905), Pallary (1938), Dantan & Heldt (1932), Steur (1939), Moazzo (1939), Barash & Danin (1972; 1977, 1992); Mienis (1971; 2004), Zenetos et al. (2012) and many others authors.

Not having found any similar species in comparison with the already reported mollusks we have further expanded our research with the comparison with non-Mediterranean species.

Species comparable to *Dizoniopsis zannii* n. sp. is the Atlantic *Cerithiopsis albobittata* (C. B. Adams, 1850) and *Cerithiopsis* sp. in Oliver, Templado & Kersting (2012) from Collubretes Is., Western Mediterranean, both with

a similar protoconch; by Oliver et al. (2015: 127, fig. 77) from Chafarinas Is. (Melilla, Southwestern Mediterranean, Spain), we did not find comparable Indo-Pacific species.

*Cerithiopsis carlottae* n. sp. is compared with the Atlantic species *Cerithiopsis greenii* (C. B. Adams, 1839), al., 2009, *Cerithiopsis aralia* Olsson & Arbison, 1953, *Cerithiopsis fusiformis* (C. B. Adams, 1850), *Cerithiopsis dominguezi* Rolán & Espinosa, 1995, *Cerithiopsis* sp. in Peñas et al., 2009, *Cerithiopsis aralia* Olsson & Arbison, 1953, from the Pliocene of Souther Florida and *Cerithiopsis* sp. from Cannizzaro (Catania).

## Acronyms and abbreviation

<i>sp. n.</i>	new species
<i>spm</i>	speciment
et al.	et alii (lat.), and others
SEM	Scanning Electron Microscope
MNHN	Muséum National d'Histoire Naturelle, Paris, France.

## Systematics

Superfamily Triphoroidea Gray, 1847

Family Cerithiopsidae H. Adams & A. Adams, 1853

Subfamily Cerithiopsinae H. Adams & A. Adams, 1853

Genus *Dizoniopsis* Sacco, 1895

(Type species: *Cerithium bilineatum*† Hoernes, 1848  
by original designation)



*Dizionopsis zannii* sp. n.  
(Figs 1 A-C)

### Type material

Holotype: (MNHN-IM-2000-33566), 2.98 x 0.94 mm, protoconch 0.55 x 0.33 mm.

### Type locality

Torre Zozzoli (Taranto, Italy).

### Material examined

Torre Zozzoli (Taranto, Italy), sediments of mud and sand, 80 m, spm 1.

### Description of the holotype

Shell small, small, regularly conical, straight-sided, sutures channeled, last whorl slightly contracted, color pale brown (slightly discolored). Protoconch conical of 4.5 slightly convex whorls, protoconch 1 smooth, apex spherical, protoconch 2 of about 3.2 which shows above the sutures a thin thread well evident in the last whorl, under a narrow band sculptured by thin prosocline axial riblets. See under SEM the surface, above and below the sutures, shows a slight graininess. Transition to teleoconch damaged. Teleoconch of six flat whorls, reticular sculpture of two spiral cords (the second bigger), crossed by weaker axial ribs (about 14 on last whorl); at each intersection there are prominent and acute beads, which give a rough look at the shell. From the insertion of the outer lip a third smooth spiral cord emerges; the limit between the columella and last whorl is marked by a fourth cord. Acuminate columella crossed by thin growth lines, a ridge bordering the oval aperture, siphonal canal and anal sulcus well defined, outer lip partially damaged.

### Comparison

For its features, *Dizoniopsis zannii* sp. n. it is easily identifiable; such a protoconch has never been observed among the known Mediterranean species and the sculpture of the teleoconch of 2 spiral cords assigns it to the genus *Dizoniopsis*.

On the basis of our research, the specimen without protoconch and without the last whorls reported as *Dizoniopsis* sp. by Oliver et al. (2015: 127, fig. 77), from Chafarinas Is. (Melilla, Southwestern Mediterranean), might be this species.

*D. zannii* can only be compared with shells similar in feature and having a protoconch smooth with a thin adapical spiral cord. After our bibliographic research it is compared with: *Cerithiopsis albovittata* (C. B. Adams, 1850), from the Caribbean, protoconch of 5 whorls, cream color, sutures marked by a series of minute grains and *Cerithiopsis* sp. (p. 67, figs. 49-53), in Oliver et al. (2012), from Columbretes Islands (Western Mediterranean), proto-

conch of 4.5 convex whorls; both have a teleoconch with a sculpture of 3 spiral granulous cords, not 2 as in *D. zannii*, main feature of the genus *Dizoniopsis*.

### Etymology

Dedicated to Paolo Zanni of Ravenna (Italy), malacologist and member of the SIM (Soc. Italiana di Malacologia).

Genus *Cerithiopsis* Forbes & Hanley, 1850  
(type species: *Murex tubercularis* Montagu, 1803 by original name)

*Cerithiopsis carlottae* sp. n.  
(Figs 1. D-E, G-I, J-L)

### Type material

Holotype: (MNHN-IM-2000-33567), 2.12 x 0.72 mm, protoconch 0.45 x 0.29 mm, Castellammare di Stabia (Napoli, Italy).

Paratype 1: 2.18 x 0.72 mm, protoconch 0.40 x 0.30 mm (Zanni coll.), Malaga, Spain.

Paratype 2: 1.99 x 0.74 mm, protoconch 0.48 x 0.33 mm (Zanni coll.), Malaga, Spain.

### Type locality

Castellammare di Stabia (Napoli, Italy).

### Material examined

Castellammare di Stabia (Napoli, Italy), sediments of mud and sand, 44 m, spm 1; Malaga, Spain, sediments of mud and sand, 110 m, spms 2.

### Description of the holotype

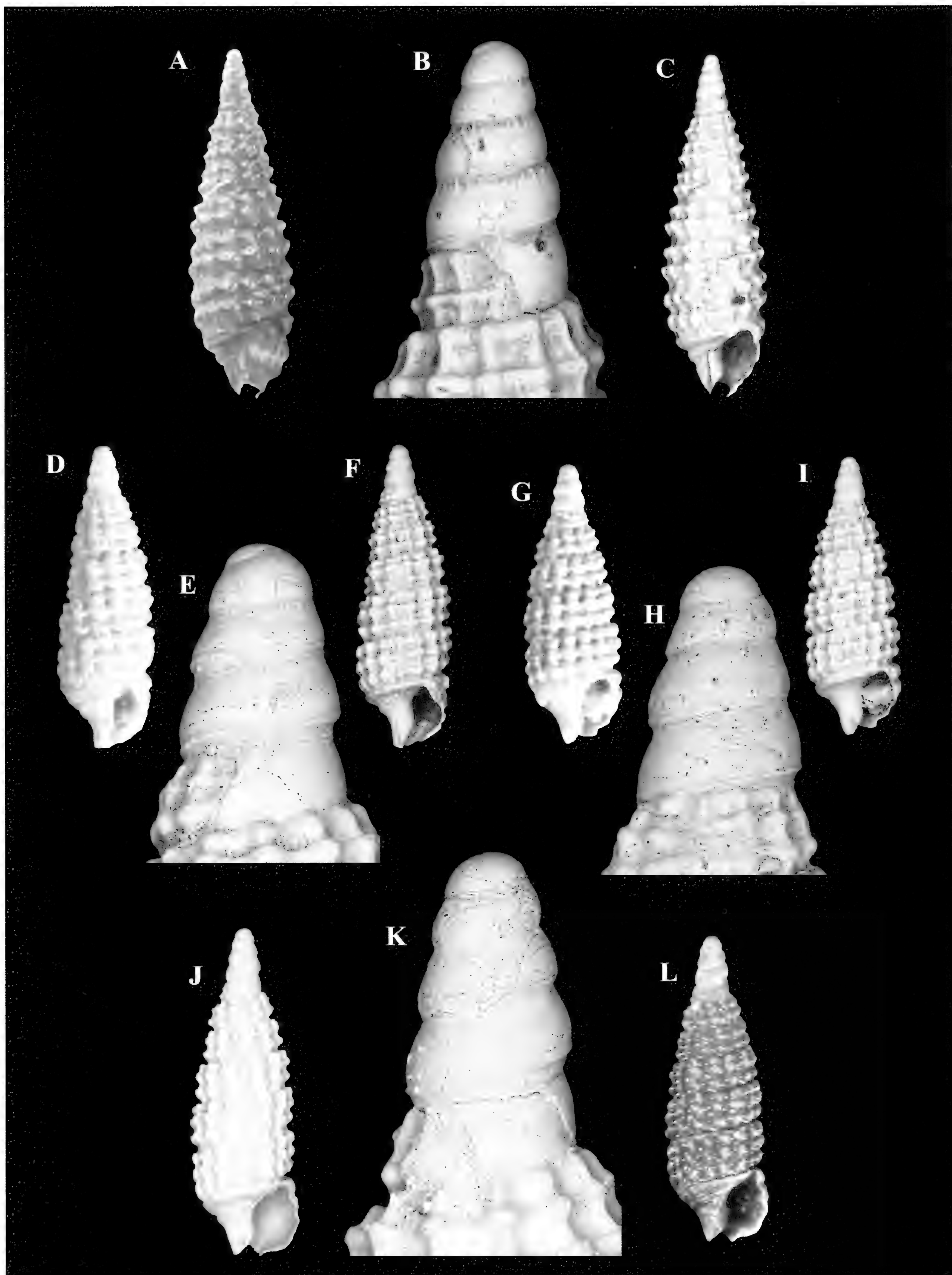
Shell small, conical, slightly inflated, sutures channeled, color pale brown (discolored). Conical protoconch of 4.5 convex smooth whorls, protoconch 2 shows a thin thread above the sutures. Transition to teleoconch marked by a sinusigera lip. Teleoconch of 5.5 whorls, reticular sculpture of three equal spiral cords (first two cords closer in the first whorls), crossed by weaker axial ribs (about 16 on last whorl), with beads at each intersections. A fourth spiral cord emerging from the insertion of the outer lip; limit between the columella and the last whorl marked by a fifth thin cord. Columella short, obliquely truncate; ridge bordering an oval aperture with siphonal canal and anal sulcus well defined.

### Comparison

The specific separation from other Mediterranean species of the genus *Cerithiopsis* is possible only by accurate observation of the protoconch.

For comparison with *C. carlottae* have been identified four similar species from the Caribbean and one fossil from South Florida (USA).





**Fig. 1. A, C.** *Dizoniopsis zannii* sp. n. (MNHN-IM-2000-33566) loc. Torre Zozzoli (Taranto, Italy), 2.98 x 0.94 mm, protoconch 0.55 x 0.33 mm, 80 m; **D, F.** *Cerithiopsis carlottae* sp. n. (Paratype 1), loc. Malaga, Spain, 2.18 x 0.72 mm, protoconch 0.40 x 0.30 mm, 110 m, (P. Zanni coll.); **G, I.** *C. carlottae* sp. n. (Paratype 2), loc. Malaga, 1.99 x 0.74 mm, protoconch 0.48 x 0.33 mm, 110 m, (P. Zanni coll.); **J, L.** *C. carlottae* sp. n. (Holotype), (MNHN-IM-2000-33567), loc. Castellammare di Stabia (Napoli, Italy), 2.18 x 0.72 mm, protoconch 0.45 x 0.20 mm, - 44 m.

**Fig. 1. A, C.** *Dizoniopsis zannii* sp. n. (MNHN-IM-2000-33566), loc. Torre Zozzoli (Taranto, Italy), 2.98 x 0.94 mm, protoconca 0.55 x 0.33mm, 80 m; **D, F.** *Cerithiopsis carlottae* sp. n. (Paratipo 1), loc. Malaga, Spain, 2.18 x 0.72 mm, protoconch 0.40 x 0.30 mm, 110 m, (coll. P. Zanni); **G, I.** *C. carlottae* sp. n. (Paratype 2), loc. Malaga, 1.99 x 0.74 mm, protoconch 0.48 x 0.33 mm, 110 m, (coll. P. Zanni); **J, L.** *C. carlottae* sp. n. (Holotype), (MNHN-IM-2000-33567), loc. Castellammare di Stabia (Napoli, Italy), 2.18 x 0.72 mm, protoconch 0.45 x 0.20 mm, - 44 m.



1) *Cerithiopsis greenii* (C. B. Adams, 1839). Adams' description of the protoconch of *C. greenii* was simply "apical [sic] ones smooth, nearly white and pearly." Common in Florida, Gulf of Saint Lawrence and Canada. Figured by Gould, 1870; Abbott, 1954; Thiriot-Quievreux, 1980; Rolán & Espinosa, 1995; Redfern, 2001; Rolán et al., 2007; Rolán et al., 2012; Krisberg & Lee, 2014.

2) *Cerithiopsis fusiformis* (C. B. Adams, 1850) having a teleoconch very similar but with the protoconch of four whorls angled to the periphery. Figured by Diaz et al. 1994; Rolán & Espinosa, 1995; Redfern, 2001; Rolán et al., 2012; Figueira & Pimenta, 2008.

3) *Cerithiopsis dominguezii* Rolán & Espinosa, 1995 (figs. 17, 18, and 19), figured by Redfern, 2001 and Rolán et al., 2012; this species has a protoconch of five smooth, less convex whorls with a thin spiral threads on the protoconch and a more elongated teleoconch.

4) *Cerithiopsis* sp. in Peñas et al., 2009: 33, figs. 6-7. The species has a very similar teleoconch but the protoconch shows, above the spiral thread, a very thin band of minute axial ribs absent in *C. carlottae*.

5) *Cerithiopsis aralia* Olsson & Arbison, 1953, fossil of Pliocene of South Florida, is mentioned for the similarity of its protoconch with that of *C. carlottae*. Odè (1989), publish the SEM photo of the protoconch of a specimen from the Northwest Mexico.

Interesting reporting in "Forum", the website of SIM, on 18 gen 2015; F. Roncone publishes the photo of *Cerithiopsis* sp., from Cannizzaro (Catania) depth 40 m, writing "la protoconca è liscia e vedo una carena spirale sul secondo giro" that, without doubts, is *C. carlottae*.

We did not find comparable species from Indopacific areas.

## Etymology

The species is dedicated to Carlotta Zanni of Ravenna (Italy), daughter of Paolo Zanni.

## Acknowledgements

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# New data on the deep-sea mollusc fauna of the Western Mediterranean (between Capraia island and Cape Corso)

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### Abstract

Sediment residue from deep-water trawling for prawn, between Capraia island and Capo Corso (Western Mediterranean Sea) between ca. 450-500 m has provided mollusc fractions containing a malacofauna rich of 115 species, mainly benthonic, and of bathyal level. With a few exceptions, most of the mollusc fauna is represented by empty, often fresh shells, with few live taken, including many rare or poorly known taxa.

### Key Words

Tuscan Archipelago, Western Mediterranean Sea, deep-sea, molluscs.

### Riassunto

[Nuovi dati sulle malacofaune batiali del Mediterraneo occidentale tra Capraia e Capo Corso]. Residui di pesca a strascico per scampi fra 450-500 m, tra Capraia e Capo Corso hanno fornito campioni contenenti una malacofauna comprendente 115 specie, prevalentemente bentoniche e di ambiente batiale, rappresentate in maggioranza da conchiglie vuote ma fresche, e in parte minore da esemplari viventi, con molti taxa rari o poco conosciuti.

### Parole chiave

Arcipelago Toscano, Mediterraneo occidentale, mare profondo, molluschi.

## Introduction

A consistent scientific literature considers the deep-water molluscs of the Ligurian and Tyrrhenian waters (Western Mediterranean), which proves to be home of many interesting species. In this context, one important sector is the Tuscan Archipelago whose bathyal mollusc fauna has been investigated in the last 30 years (Cecalupo & Giusti 1986; Giusti & Nofroni, 1995; Bogi & Campani, 2005; Giusti et al. 2015; Romani et al. 2016). Nevertheless, the comprehensive knowledge of this fauna is yet to be achieved and the present paper comments upon new records, which also include rare molluscs from this area, based upon the examination of sea-bottom samples provided through commercial fishing activity.

## Material and methods

The source of the material considered in this study is a sample of ca. 12 kg of grey mud sediment, taken between 450-500 by a trawler between Capraia island and Cape Corso at approximately 43°10' Lat. N and 9°40' Long. E.

The sediment has been disaggregated with hydrogen peroxide, dried and then sieved to concentrate its biological content.

Picking of the mollusc component has been performed using a stereo microscope. Taxonomic classification follows the World Register of Marine Species (WoRMS) and "Sistematica mediterranea".

Abbreviations and acronyms are as follows: fr: fragment; sh: shell, indicates gastropod without soft parts or articulated bivalve not containing remains of soft parts; spm: specimen, indicates gastropod complete of soft parts or bivalve containing remains of soft parts; v: loose valve.

## Results

The component Mollusca comprises >3000 gastropod between shells and specimens, and several hundred bivalves, predominantly loose valves but also articulated shells, plus a modest representation from other classes. Although the dominant component is represented by benthic molluscs (subordinately holoplanktic), other skeletal remains have been identified in the biogenic assemblage. For instance, we have identified 'white coral' fragments (*Madrepora oculata* Linnaeus, 1767, and *Lophelia pertusa*, 1758), the bryozoan *Tervia barrieri* Rosso, 1998 (A. Rosso, pers com., 3 July 2017) and the decapod crustacean *Nephrops norvegicus* (Linné, 1758). The latter is consistent with the typology of the fishing boat that was, in fact, mostly trawling for prawn. The finest fraction has not been considered in any detail for this study.

The molluscs identified at species level are listed in Table 1 totalizing 115 taxa. Gastropoda predominate upon the other classes with 75 species (65 benthic and 10 holoplanktic), followed by Bivalvia (34 species). Scaphopoda (3 species), Polyplacophora (2 species) and Monoplacophora (1 species). The mol-



luscan diversity recorded by the trawling residue from a relatively restricted area is remarkable and compares well with other Mediterranean situations such as, for example, the ‘white coral’ grounds of Santa Maria di Leuca in the northern Ionian Sea, characterized by a mosaic of intermixed hard and soft substrates (Mastrototaro et al. 2010, Rosso et al. 2010). The recent update provided by Negri et al. (2016) cense, in fact, 108 species, a figure comparable with our case-study. *Propilidium exiguum*, *Fissurisepta granulosa*, *Anatoma aspera*, *Danilia costellata*, *Alvania cimicoides*, *Alvania subsoluta*, *Amphissa acutecostata*, *Ledella messanensis*, *Yoldiella philippiana*, *Notolimea crassa*, *Kelliella miliaris* and *Abra longicallus* are the most abundant species, Although our mollusc fauna is coherent with the sampling depth, being mostly constituted by epibathyal benthic molluscs, the assemblage contains also some allochthonous species (*Bittium* ssp., *Tricolia pullus*, *Alvania lanciae*, etc.), displaced from shallower (photic) habitats. A similar situation has been observed elsewhere in the Mediterranean Sea (Bonfitto et al. 1994).

A recurrent situation regarding the deep-sea mollusc assemblages of the Mediterranean Sea is the occurrence of Pleistocene shells mixed with the recent (Holocene) component (Taviani 1974, 1978, Di Geronimo & Li Gioi 1981, Taviani & Sabelli 1983, Guidastri et al. 1984, Di Geronimo & Bellagamba 1986, Taviani & Taviani 1986, Bonfitto et al. 1994, Bogi & Campani 2005, López Correa et al. 2005, Remia and Taviani 2005, Taviani et al. 2009, Romani et al. 2016). In most cases the age attribution (rather typically the last glacial epoch) is not certain but putative, and relies upon the lack of live-collected individuals in the basin and the preservation of the shells. On the basis of the freshness of the material here considered, we hypothesize that even empty shells are recent and do not belong to fossil assemblages.

Taxonomic remarks

The mollusk assemblage under scrutiny contains many rare and interesting species, some of which only seldom treated in the literature. Here we provide some discussion on some such taxa.

**Gastropoda Cuvier, 1795**  
Family Fissurellidae Fleming, 1822  
*Emarginula crassa* J. Sowerby, 1813

(Fig. 1. A, B)  
Material: 1sh. + 1 fr.

The first Mediterranean record of this interesting taxon is due to Giusti et al. (2015) from off Capo Corso (-600m) and Gorgona island (-500m). This bathyal species is presently distributed in North-eastern Atlantic and also known from the Pleistocene deposits in southern Italy (Micali & Villari, 1989; Rindone & Vazzana, 1989). Our material appears fresh but without soft parts, leaving open the question whether this species is still alive in the Mediterranean Sea.

Superfamily Seguenzioidea Verrill, 1884  
*Adeuomphalus ammoniformis* Seguenza G., 1876  
(Fig. 1. C-E)

Material: 39 sh.  
This minute species has been often reported for the Tyrrhenian sea but all such records pertain to empty shells only (Nofroni & Sciubba, 1985; Cecalupo, 1986; Palazzi, 1988; Smriglio, Mariottini & Gravina, 1988; Ardovini & Cossignani, 1999) It equally occurs in other sectors of the Western Mediterranean, where it has been found alive at bathyal depths (Rubio Salazar 2011; Gofas et al. 2014). Kano et al. (2009) summarize the records of this

Table 1

SPECIES	Number	Substrate
MONOPLACOPHORAN		
<i>Veleropilina reticulata</i> (Seguenza G., 1876)	35 sh.	
POLYPLACOPHORA		
<i>Hanleya hanleyi</i> (Bean in Thorpe, 1844)	1 v.	hard
<i>Stenosemus dolii</i> (Van Belle & Dell’Angelo, 1998)	7 v.	hard
GASTROPODA		
<i>Propilidium exiguum</i> (Thomson, 1843)	> 800 sh.	hard
<i>Emarginula crassa</i> J. Sowerby, 1813	1sh.+ 1 fr.	hard
<i>Emarginula multistriata</i> Jeffreys, 1882	1 sh.	hard
<i>Emarginula adriatica</i> Costa O.G., 1829	1 sh.	hard
<i>Emarginula tenera</i> Locard, 1892	6 sh.	hard
<i>Fissurisepta granulosa</i> Jeffreys, 1883	> 400 sh.	hard
<i>Anatoma aspera</i> (Philippi, 1844)	> 200 sh.	mud
<i>Bogia labronica</i> (Bogi, 1984)	3 sh.	?



<i>Addisonia excentrica</i> (Tiberi, 1855)	1 sh.	inside fish egg capsule
<i>Copulabyssia corrugata</i> (Jeffreys, 1883)	20 sh.	on sunken wood
<i>Cirsonella romettensis</i> (Granata Grillo, 1877)	> 120 sh.	mud
<i>Putzeysia wiseri</i> (Calcara, 1842)	25 sh. + 1 spm.	mud / hard
<b><i>Adeuomphalus ammoniformis</i> Seguenza G., 1876</b>	39 sh.	sponges?
<i>Danilia costellata</i> (O.G. Costa, 1861)	> 250 sh.	gravel/ hard/ coral
<i>Akritogyra conspicua</i> (Monterosato, 1880)	2 sh.	?
<i>Anekes sculpturata</i> Warén, 1991	9 sh.	?
<i>Lissotesta turrita</i> (Gagliini, 1987)	1 sh.	?
<i>Moelleriopsis messanensis</i> (Seguenza, 1876)	> 600 sh.	mud
<i>Cantrainea peloritana</i> (Cantraine, 1835)	14 sh. + some opercula	various
<b><i>Rugulina fragilis</i> (G.O. Sars, 1878)</b>	8 sh.	?
<b><i>Rugulina monterosatoi</i> (van Aartsen &amp; Bogi, 1987)</b>	6 sh.	
<i>Trochaclis versiliensis</i> Warén, Carrozza & Rocchini, 1992	30 sh.	?
<b><i>Bathysciadium xylophagum</i> Warén &amp; Carrozza in Warén, 1996</b>	1 sh.	wood
<i>Krachiopsis giannuzzii</i> Smriglio & Mariottini, 2000	1 sh.	?
<i>Cerithiopsis fayalensis</i> Watson, 1886	5 sh.	?
<i>Punctiscala cerigottana</i> (Sturany, 1896)	1 fr.	parasitic Anthozoa indet.
<i>Epitonium tiberii</i> (De Boury, 1890)	1 sh.	parasitic Anthozoa indet.
<b><i>Iphitus marshalli</i> (Sykes, 1925)</b>	3 sh. + 1 fr.	parasitic Scleractinia
<i>Aclis attenuans</i> Jeffreys, 1883	1 sh.	?
<b><i>Haliella tyrrhena</i> Di Geronimo &amp; La Perna, 1999</b>	4 sh.	parasitic?
<i>Alvania cancellata</i> (da Costa, 1778)	1 sh.	sand/hard
<i>Alvania cimicoides</i> (Forbes, 1844)	> 400 sh.	mud / sand / hard
<i>Alvania electa</i> (Monterosato, 1874)	35 sh.	mud
<i>Alvania subsoluta</i> (Aradas, 1847)	> 200 sh. + 2 spm.	mud
<i>Alvania testae</i> (Aradas e Maggiore, 1844)	> 90 sh.	mud / sand
<i>Alvania zetlandica</i> (Montagu, 1815)	1 sh.	mud / sand
<i>Benthonella tenella</i> (Jeffreys, 1869)	40 sh. + 4 spm.	mud
<i>Laeviphitus verduini</i> van Aartsen, Bogi & Giusti, 1989	40 sh.	?
<i>Aporrhais serresianus</i> (Michaud, 1828)	2 sh.	mud
<i>Carinaria lamarckii</i> Blainville, 1817	1 fr.	pelagic
<i>Protatlanta souleyeti</i> (Smith E.A., 1888)	several fr.	pelagic
<i>Atlanta brunnea</i> J.E. Gray, 1850	several fr.	pelagic
<i>Atlanta helicinoidea</i> J.E. Gray, 1850	several fr.	pelagic
<i>Pagodula echinata</i> (Kiener, 1840)	12 sh.	mud
<i>Coralliophila panormitana</i> (Monterosato, 1869)	5 sh.	coral
<i>Nassarius lima</i> (Dillwin, 1817)	10 sh.	mud
<i>Amphissa acutecostata</i> (Philippi, 1844)	> 600 sh.	sand / mud
<i>Drilliola loprestiana</i> (Calcara, 1841)	2 sh.	sand / mud
<i>Teretia teres</i> (Reeve, 1844)	2 sh.	sand / mud
<i>Taranis laevisculpta</i> Monterosato, 1880	1 sh.	mud
<i>Heliacus alleryi</i> (Seguenza G., 1876)	7 sh.	coral
<i>Mathilda cochlaeformis</i> Brugnone, 1873	1 sh.	mud / sand
<i>Mathilda coronata</i> Monterosato, 1875	22 sh.	mud / sand
<b><i>Tuba jeffreysi</i> (Dall, 1889)</b>	10 sh.	?
<i>Kongsrudia stefanisi</i> (Jeffreys, 1869)	1 sh.	parasitic
<i>Turbonilla micans</i> (Monterosato, 1875)	4 sh.	mud / parasitic
<b><i>Eulimella cf. ventricosa</i> (Forbes, 1844)</b>	6 sh.	mud / parasitic
<i>Xylodiscula boucheti</i> Warén et al., 1992	> 40 sh.	?



<i>Cima minima</i> (Jeffreys, 1858)	11 sh. + 4 spm.	?
<i>Xylodiscula lens</i> Warén, 1992	21 sh.	mud
<b><i>Orbitestella dariae</i> (Liuzzi &amp; Zucchi-Stolfa, 1979)</b>	> 40 sh. + 1 spm.	mud
<i>Tjaernoeia exquisita</i> (Jeffreys, 1883)	1 sh.	?
<i>Tjaernoeia unisulcata</i> (Chaster, 1896)	1 sh.	?
<i>Hyalogyrina amphorae</i> Warén et al., 1997	> 20 sh.	mud
<b><i>Melanochlamys seurati</i> (Vayssiere, 1926)</b>	1 sh.	sand
<i>Diaphana cretica</i> (Forbes, 1844)	10 sh.	mud
<i>Cavolinia inflexa</i> (Lesueur, 1813)	> 40 sh.	pelagic
<i>Clio pyramidata lanceolata</i> (Lesueur, 1813)	> 30 sh.	pelagic
<i>Creseis clava</i> Rang, 1828	6 sh.	pelagic
<i>Creseis conica</i> Eschscholtz, 1829	30 sh.	pelagic
<i>Limacina bulimoides</i> (D’Orbigny, 1836)	> 20 sh.	pelagic
<i>Limacina trochiformis</i> (D’Orbigny, 1836)	1 sh.	pelagic
<i>Heliconoides inflatus</i> (D’Orbigny, 1834)	20 sh.	pelagic
<i>Gleba cordata</i> Niebuhr, 1776 ex Forskål ms.	1 sh.	pelagic
<i>Peracle reticulata</i> (D’Orbigny, 1836)	10 sh.	pelagic
BIVALVIA		
<i>Ennucula aegeensis</i> (Forbes, 1844)	1 spm., 5 sh. + 10 v.	mud
<i>Pristigloma minima</i> (Seguenza G., 1877)	15 sh. + several v.	mud
<i>Ledella marisnostri</i> La Perna, 2004	About 50 sh. + several v.	mud
<i>Ledella messanensis</i> (Jeffreys, 1870)	23 sh. + over 100 v.	mud
<b><i>Yoldiella cf. frigida</i> (Torell, 1859)</b>	1 sh.	
<b><i>Yoldiella nana</i> (M. Sars, 1865)</b>	1 sh.	
<i>Yoldiella ovulum</i> La Perna, 2004	3 sh. + over 10 v.	mud
<i>Yoldiella philippiana</i> (Nyst, 1845)	3 spm., 12 sh. + over 100 v.	mud
<i>Yoldiella wareni</i> La Perna, 2004	4 v.	mud
<i>Microgloma tumidula</i> (Monterosato, 1880)	2 spm., 43 sh. + valves	?
<i>Asperarca nodulosa</i> (Müller O.F. 1776)	27 sh. + over 200 v.	hard
<i>Idas simpsoni</i> (Marshall, 1900)	Some sh. + several v.	wood/bone boring
<i>Bathyarca pectunculoides</i> (Scacchi, 1834)	> 30 v.	hard
<i>Cyclopecten hoskynsi</i> (Forbes, 1844)	>	mud
<i>Delectopecten vitreus</i> (Gmelin, 1791)	4 sh. + several v.	hard
<i>Spondylus gussonii</i> Costa O.G., 1829	About 15 sh. + several v.	hard
<i>Heteranomia squamula</i> (Linnaeus, 1758)	> 10 v.	hard
<i>Limatula subauriculata</i> (Montagu, 1808)	> 30 v.	mud/sand/gravel
<i>Limea crassa</i> (Forbes, 1844)	2 spm. + over 50 v.	mud
<i>Myrtea amorpha</i> (Sturany, 1896)	6 sh. + few v.	sand/gravel
<i>Lucinoma borealis</i> (Linnaeus, 1767)	2 sh. + few v.	sand/gravel
<i>Thyasira biplicata</i> (Philippi, 1836)	2 v.	mud
<i>Thyasira granulosa</i> (Monterosato ex Jeffreys ms, 1874)	1 v.	mud
<i>Thyasira subovata</i> (Jeffreys, 1881)	2 v.	mud
<i>Genaxinus eumyarius</i> (M. Sars, 1870)	1 v.	mud
<i>Mendicula ferruginosa</i> (Forbes, 1844)	1 v.	mud/sand
<i>Abra longicallus</i> (Scacchi, 1834)	> 50 sh. + hundreds v.	mud
<i>Kelliella miliaris</i> (Philippi, 1844)	2 spm., over 50 sh. + hundreds v.	mud
<i>Saxicavella jeffreysi</i> Winckworth, 1930	1 spm. + 5 v.	mud
<i>Cetomya neaeroides</i> (Seguenza, 1877)	5 sh. + some v.	mud



<i>Cuspidaria rostrata</i> (Spengler, 1793)	1 v.	mud
<i>Tropidomya abbreviata</i> (Forbes, 1843)	1 v.	mud
<i>Cardiomya costellata</i> (Deshayes, 1835)	1 sh. + 6 v.	mud/sand/gravel
<i>Halonympha depressa</i> (Jeffreys, 1882)	1 sh.	mud
SCAPHOPODA		
<i>Antalis agilis</i> (Sars M., 1872)	1 sh.	mud
<i>Entalina tetragona</i> (Brocchi, 1814)	> 25 sh.	mud
<i>Cadulus subfusiformis</i> Sars M., 1875	> 20 sh.	mud

The name in bold indicates that species is discussed in the text.

species and comment upon the putative trophic habitus of *Adeuomphalus* by suggesting that “may feed on the sponges or possibly micro-crustaceans accumulated on their surface”.

Family Pendromidae Warén, 1991  
*Rugulina fragilis* (G. O. Sars, 1878)  
(Fig. 1. F-H)

Material: 8 sh.  
An uncommon NE Atlantic taxon recently recorded in the Mediterranean Sea off Capo Corso at 600m (Giusti et al. 2015). Our material consists of empty but fresh-looking shells.

*Rugulina monterosatoi* (van Aartsen & Bogi, 1987)  
(Fig. 1. I, K)

Material: 6 sh.  
Species reported by Giusti et al. (2015) from various sites of the Tuscan Archipelago, between 300-600 m. Even in this case the shell is without soft parts inside, but very fresh.

Family Bathysciadiidae Dautzenberg & H. Fischer, 1900  
*Bathysciadium xylophagum* Warén & Carrozza  
in Warén, 1996  
(Fig. 1. L, M)

Material: 1 sh.  
A species originally described upon specimens from SE Sardinia at depth of 630 m, inhabiting tunnels produced by ship-worms in sunken wood. We found a single empty shell of this rare species

Family Nystiellidae Clench & Turner, 1952  
*Iphitus marshalli* (Sykes, 1925)  
(Fig. 1. N, O)

Material: 3 sh. plus one fragment.  
An exceedingly rare species known in the NE Atlantic off Portugal and the Strait of Gibraltar (Bouchet & Warén 1986). This taxon, likely parasitic on scleractinian corals has been previously reported for the Mediterranean Sea from La Galite archipelago (Tunisia) at 650 m (Ardovini & Cossignani 1999). Our material consists of

two shells and one fragment, very fresh and with the protoconch retaining its reddish color, so that we do not exclude the option that *I. marshalli* is still living in this area at present.

Family Eulimidae Philippi, 1853  
*Haliella tyrrhena* Di Geronimo & La Perna, 1999  
(Fig. 1. P, Q)

Material: 4 sh.  
This deep-water species, originally described upon Holocene subfossil material, is reported from various localities of the Tuscan Archipelago between 400-500 m. A rather fresh specimen is figured by Romani et al. (2016). Our shells are also very fresh and transparent, suggesting that the species still inhabits these waters at present.

Family Mathildidae Dall, 1889  
*Tuba jeffreysi* (Dall, 1889)  
(Fig. 1. R)

Material: 10 sh.  
This Atlantic species was first reported in the Mediterranean by Giusti & Nofroni (1995), based on fresh shells found off Capraia island between 380-440 m. Our material is equally very fresh, showing brown-colored spiral cords.

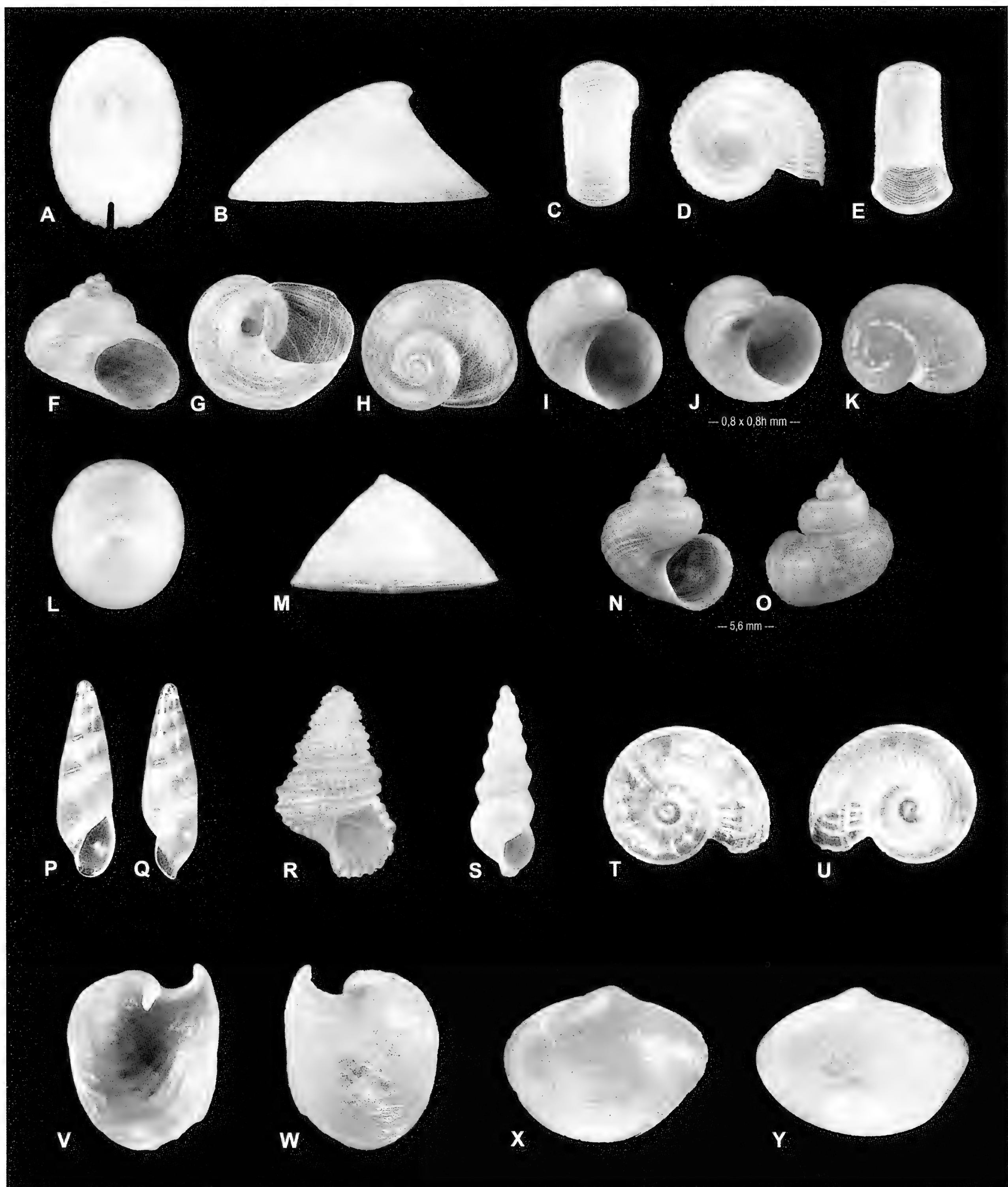
Family Pyramidellidae J.E. Gray, 1840  
*Eulimella* cf. *ventricosa* (Forbes, 1844)  
(Fig. 1. S)

Material: 1sh.  
This species is frequently found in deep water samples. One of the specimens shows a very unusual whorl profile, with a central angularity, although the protoconch does not differ from typical *E. ventricosa* of which it may represent a freak shell.

Family Orbitestellidae Iredale, 1917  
*Orbitestella dariae* (Liuzzi & Zucchi-Stolfa, 1979)  
(Fig. 1. T, U)

Material: One specimen and > 40 sh.  
An elusive species described upon beached shells found at Salvore (Croatia), in the north-eastern Adriatic Sea. but later recorded off Civitavecchia (Tyrrhenian Sea) at





**Fig. 1** **A, B.** *Emarginula crassa* J. Sowerby, 1813, N-W Capraia, -450-500 m, l = 21 mm; **C-E.** *Adeuomphalus ammoniformis* Seguenza G., 1876, N-W Capraia, -450-500 m, d = 1.2 mm; **F-H.** *Rugulina fragilis* (G. O. Sars, 1878), N-W Capraia, -450-500 m, h = 1.5 mm; **I-K.** *Rugulina monterosatoi* (van Aartsen & Bogi, 1987), N-W Capraia, -450-500 m, h = 0.8 mm; **L, M.** *Bathysciadium xylophagum* Warén & Carrozza in Warén, 1996, N-W Capraia, -450-500 m, d = 4 mm; **N, O.** *Iphitus marshalli* (Sykes, 1925), N-W Capraia, -450-500 m, h = 5.6 mm; **P, Q.** *Haliella tyrrhena* Di Geronimo & La Perna, 1999, N-W Capraia, -450-500 m, h = 2.4 mm; **R.** *Tuba jeffreysi* (Dall, 1889), -450-500 m, h = 5.3 mm; **S.** *Eulimella* cf. *ventricosa* (Forbes, 1844), N-W Capraia, -450-500 m, h = 2.8 mm; **T, U.** *Orbitestella dariae* (Liuzzi & Zucchi-Stolfa, 1979), N-W Capraia, -450-500 m, h = 1 mm; **V, W.** *Melanochlamys seurati* (Vayssiére, 1926), N-W Capraia, -450-500 m, h = 4.3 mm; **X.** *Yoldiella* cf. *frigida* (Torell, 1859), N-W Capraia, -450-500 m, antero-posterior diam. = 3.2 mm; **Y.** *Yoldiella nana* (M. Sars, 1865), N-W Capraia, -450-500 m, antero-posterior diam. = 3.4 mm.

**Fig. 1** **A, B.** *Emarginula crassa* J. Sowerby, 1813, N-W Capraia, -450-500 m, l = 21 mm; **C-E.** *Adeuomphalus ammoniformis* Seguenza G., 1876, N-W Capraia, -450-500 m, d = 1,2 mm; **F-H.** *Rugulina fragilis* (G. O. Sars, 1878), N-W Capraia, -450-500 m, h = 1,5 mm; **I-K.** *Rugulina monterosatoi* (van Aartsen & Bogi, 1987), N-W Capraia, -450-500 m, h = 0,8 mm; **L-M.** *Bathysciadium xylophagum* Warén & Carrozza in Warén, 1996, N-W Capraia, -450-500 m, d = 4 mm; **N, O.** *Iphitus marshalli* (Sykes, 1925), N-W Capraia, -450-500 m, h = 5,6 mm; **P, Q.** *Haliella tyrrhena* Di Geronimo & La Perna, 1999, N-W Capraia, -450-500 m, h = 2,4 mm; **R.** *Tuba jeffreysi* (Dall, 1889), -450-500 m, h = 5,3 mm; **S.** *Eulimella* cf. *ventricosa* (Forbes, 1844), N-W Capraia, -450-500 m, h = 2,8 mm; **T, U.** *Orbitestella dariae* (Liuzzi & Zucchi-Stolfa, 1979), N-W Capraia, -450-500 m, h = 1 mm; **V, W.** *Melanochlamys seurati* (Vayssiére, 1926), N-W Capraia, -450-500 m, h = 4,3 mm; **X.** *Yoldiella* cf. *frigida* (Torell, 1859), N-W Capraia, -450-500 m, diam. antero-posteriore = 3,2 mm; **Y.** *Yoldiella nana* (M. Sars, 1865), N-W Capraia, -450-500 m, diam. antero-posteriore = 3,4 mm.



depth of 550 m by Ardochini & Cossignani (1999). Our finding further confirms that its habitat is likely bathyal.

Famiglia Cimidae Warén, 1993  
*Cima minima* (Jeffreys, 1858)

Material: 4 spms with remains of soft parts plus 11 sh. This species is typically found at shallow depth littoral (see Warén, 1993 and personal unpublished data), and the occurrence of living specimens in a deep-water environment is surprising. Scaperrotta et al. (2012) document a remarkable variability among specimens obtained from Giannutri Island (north Tyrrhenian Sea at -40 m). One such specimen compares well with our material.

Famiglia Aglajidae Pilsbry, 1895  
*Melanochlamys seurati* (Vayssièrè, 1926)  
(Fig. 1. V, W)

Material: 1 sh. This poorly known species is reported from shallow sandy bottoms (Micali & Scuderi, 2006), and its occurrence here may be accidental.

Yoldiidae Dall, 1908  
*Yoldiella* cf. *frigida* (Torell, 1859)  
(Fig. 1. X)

Material: 1 spm. *Yoldiella frigida* is reported in the Mediterranean by Bonfitto et al. (1994) from East Sardinia at depth of 347-551 m, in a mix of recent and Pleistocene material, with no indication on the preservation status of the specimens. It is also reported by Cecalupo & Giusti (1986) between Capraia and Cape Corso at depth of 400-440 m. Regarding this high-artic circumpolar species, Warén (1989) states “*Yoldiella frigida* has frequently, also in recent literature, been recorded from the Mediterranean, but all the specimens I have examined have been erroneously determined, and belong to *Y. nana*”. However, we believe that not all the Mediterranean records should necessarily be referred to *Y. nana*. The difference between the *Y. frigida* and *Y. nana* is mainly based on the teeth shape. At any event, our single shell, tentatively assigned to *Y. frigida*, is characterized by a very high (umbo-ventral) outline and clearly differs from *Y. nana*.

*Yoldiella nana* (M. Sars, 1865)  
(Fig. 1. Y)

Material: 1 spm. This morphologically variable species is distributed in the North Atlantic but has also been reported for the Mediterranean Sea, off Southern France at 650-770 m and in the Tuscan Archipelago off Gorgona island at 600 m (Warén 1989, Scaperrotta et al. 2014).

## Conclusions

This short note discusses deep-water molluscs trawled from one of the most studied sectors of the Mediterranean Sea. It testifies that our knowledge of the deep-sea is so imperfect that novel information can be obtained even nowadays, thus adding to the remarkable diversity of the Mediterranean mollusc fauna (Sabelli and Taviani, 2014). This contribution should, therefore, be seen as a stimulus for further investigations with special focus on the bathyal realm.

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# The Pliocenic molluscan fauna of “Le Conchiglie” (Lagune di Sasso Marconi, Bologna, Italy). Third and last contribution

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## Abstract

The malacofauna collected in the Pliocenic outcrop located at the agritourism “Le Conchiglie”, near Lagune di Sasso Marconi (Bologna, Italy), was partially studied in two previous publications. The present work advantages from the sorting out of additional material, providing an enlarged list of species and additional notes on some interesting ones. A total of 262 molluscan species are listed, but this list is most probably still incomplete. *Calliostoma sayanus* (Seguenza G., 1876) is reported for the first time in the Tosco-Emilian Pliocenic Basin.

## Key words

Marine molluscs, Palaeoecology, Pliocene, Gulf of Bologna

## Riassunto

[*La malacofauna pliocenica di “Le Conchiglie” (Lagune di Sasso Marconi, Bologna, Italia). Terzo e ultimo contributo*] Porzioni limitate della malacofauna presente all’interno dell’agriturismo “Le Conchiglie”, ubicato a Lagune di Sasso Marconi (BO), sono già state oggetto di studio. Il presente lavoro si avvantaggia dell’esame di ulteriore materiale e fornisce un quadro più ampio riguardo alla composizione di tale ricchissima associazione (allo stato attuale delle conoscenze sono state conteggiate 262 specie di Molluschi) anche se, senz’altro, ancora incompleto. *Calliostoma sayanus* (Seguenza G., 1876) viene segnalato per la prima volta nel Pliocene del bacino tosco-emiliano.

## Parole chiave

Molluschi marini, Paleoecologia, Pliocene, Golfo bolognese

## Introduction

The molluscan fauna of the agritourism “Le Conchiglie” (Lagune di Sasso Marconi, Bologna, Italy) has been studied by Bellagamba et al. (2013) and by Bellagamba & Micali (2016). The first work gave a general description of the malacofauna, with indication of trophic groups, affinity with substrata and other ecological information, while the second was focused only on Pyramidellidae. In the first work only the sub-sample C1 was quantitatively analyzed, while the present work is based on the results obtained after a more extensive examination of sub-samples. A complete list of the recorded species, including some new records from other parts of the outcrop and the revision of some records in Bellagamba et al. (2013), is given. A total of 262 species is here listed.

## Stratigraphy

As indicated in the previous works, the outcrop at “Le Conchiglie” (coordinates of the sampled point: 44°23’20.56” N; 11°10’55.62” E) is part of the Monte Adone Formation and, more precisely, in the Ganzole member, indicated by the acronym ADO 2 on sheet 237 of the Carta Geologica d’Italia (Fig. 1 in Bellagamba & Micali, 2016), consisting in fine sand, intercalated by

sandy mud of open sea, referred to Piacenzian (Ricci Lucchi et al., 1981; Colalongo et al., 1982) and more precisely dated by Bellagamba et al. (2013) between the lower and the middle Piacenzian.

The alternation in the Ganzole member of yellowish sand (indicating a littoral environment), with grey sand (indicating a deep water zone), remarked by Bellagamba & Micali (2016) could be caused by gravitational flows that caused the displacement to greater depths of more littoral material. The mixing of material from various depths is clearly indicated by the malacofauna composition (Tab. 3), that includes littoral species as well as deep-sea species.

## Material and methods

After a picking up of the exposed shells, an excavation was carried out and a volumetric sample of about 50 dm<sup>3</sup> was taken. As described in previous works (Bellagamba et al., 2013; Bellagamba & Micali, 2016), the sample was divided in 48 sub-samples following a 8x6 matrix, each identified by an alpha-numeric code (from A to H and from 1 to 6), having a dimension of 10 cm x 10 cm x 10 cm (Fig. 2 in Bellagamba & Micali, 2016). Only 17 sub-samples were examined. The sediment has been roughly broken into large pieces threatened in a warm



solution of hydrogen peroxide at 33% until complete disaggregation, dried and then sieved to concentrate its biological content. More precisely the sub-samples A1, A2, A3, A5, B1, C1, E1, e G1 (group A) have been quantitatively analyzed, while the sub-samples A4, A6, B6, D1, D6, F1, F5, G2 e G6 (group B) have been analyzed only qualitatively, to detect the occurrence of species not recorded in the previous samples. All the samples were divided in the granulometric fractions: 1) > 5 mm, 2) 2-5 mm, 3) 0.5-2 mm. Only a quarter of the finest fraction was examined. Number of bivalve specimens was counted with the method indicated by Di Geronomo & Robba (1976).

Results

A total of 262 mollusca species have been determined: some of them (53 = 37 gastropods + 13 bivalves + 3 scaphopods) have been manually collected, others picked from the bulk sample, some other (21 = 13 gastropods + 7 bivalves and the scaphopod *Paradentalium sexangulum* (Gmelin, 1791)) found in the volumetric sample but also collected by picking. The 262 species are divided as: 1 polyplacophora, 162 gastropoda (4 of which planktonic), 94 bivalvia and 5 scaphopoda. The number of specimens found in the sub-samples of groups A and B are indicated at **Tab. 1**.

	Poliplacophora	Gastropoda	Bivalvia	Scaphopoda
Group A	2	1556 (+9 planktonic)	7592	97
Group B		78 (+ 2 planktonic)	37	

**Tab. 1.** Number of specimens in the sub-samples of the “group A” and “group B”.

**Tab. 1.** Numero di esemplari nei sotto-campioni del “gruppo A” e “gruppo B”.

Considering only the “group A”, the Tab. 2 lists the species present in all the eight sub-samples, with relative abundance.

Gastropoda	number of specimens
<i>Bittium submammillatum</i> (De Rayneval & Ponzi, 1854)	251
<i>Nassarius semistriatus</i> (Brocchi, 1814)	161
<i>Ringicula auriculata</i> (Ménard de La Groye, 1811)	161
<i>Nassarius clathratus</i> (Born, 1778)	120
<i>Turritella tricarinata tricarinata</i> (Brocchi, 1814)	97
<i>Acteon semistriatus</i> (Férussac, 1822)	44
<i>Megastomia conoidea</i> (Brocchi, 1814)	33
<i>Retusa truncatula</i> (Bruguière, 1792)	29
<i>Scaphander lignarius</i> (Linnaeus, 1758)	17
Bivalvia	number of specimens
<i>Saccella commutata</i> (Philippi, 1844)	1568
<i>Spisula subtruncata</i> (da Costa, 1778)	693
<i>Lembulus pellus</i> (Linné, 1767)	652
<i>Acanthocardia echinata</i> (Linnaeus, 1758)	560
<i>Oudardia compressa</i> (Brocchi, 1814)	556
<i>Corbula gibba</i> (Olivi, 1792)	451
<i>Circomphalus foliaceolamellosus</i> (Dillwyn, 1817)	370
<i>Timoclea ovata</i> (Pennant, 1777)	334
<i>Atlantella pulchella</i> (Lamarck, 1818)	288
<i>Nucula jeffreysi</i> Bellardi, 1875	233
<i>Amusium cristatum</i> (Bronn, 1827)	203
<i>Nucula nitidosa</i> Winckworth, 1930	144
<i>Lutraria angustior</i> Philippi, 1844	108
<i>Anadara gibbosa</i> (Reeve, 1844)*	107
<i>Musculus</i> cf. <i>discors</i> (Linné, 1767)	101
<i>Gari fervensis</i> (Gmelin, 1791)	98
<i>Phaxas pellucidus</i> (Pennant, 1777)	92



<i>Dosinia lupinus</i> (Linnaeus, 1758)	87
<i>Anomia ephippium</i> Linnaeus, 1758	67
<i>Pelecypora islandicoides</i> (Lamarck, 1818)*	64
<i>Mimachlamys varia</i> (Linnaeus, 1758)	48
<i>Solen marginatus</i> Pulteney, 1799	33
<b>Scaphopoda</b>	<b>number of specimens</b>
<i>Fustiaria rubescens</i> (Deshayes, 1825)	83

**Tab. 2.** List of species, with number of specimens, present in all the eight “group A” sub-samples. The (\*) indicates that the species has been even picked-up, in a good number of specimens.

**Tab. 2.** Lista delle specie, con numero di esemplari, presenti in tutti gli otto sotto-campioni del “gruppo A”. L’asterisco (\*) indica che la specie è stata anche raccolta direttamente nel sito, in un buon numero di esemplari.

The following species have been found only in the “group B” sub-samples.

- Skenea* cf. *bogii* Chirli, 2004  
*Skenea* sp.  
*Obtusella intersecta* (Wood, 1857)  
Naticidae juv.  
*Eccliseogyra* sp.  
*Melanella* sp. 1  
*Cyllene paulucciana* (D’Ancona, 1864)  
*Nassarius planicostatus* (Bellardi, 1882)  
*Mangelia attenuata* (Montagu, 1803)  
*Odostomia perturrita* (Fekih, 1969)  
*Noemiamea dolioliformis* (Jeffreys, 1848)  
*Parthenina curvicostata* (Wood, 1848)  
*Turbonilla lancae* Libassi, 1859  
*T. plicatulasenensis* Sacco, 1892  
*T. subalpina* Sacco, 1892  
*Turbonilla* sp. 2 (n.sp.?)  
*Retusa umbilicata* (Montagu, 1803)  
*Striarca* sp.  
*Cardium* sp.

- Cardium* sp.?  
*Parvicardium minimum* (Philippi, 1836)  
*Parvicardium* sp.  
*Donax* sp.  
*Ruditapes decussatus* (Linnaeus, 1758)

In **Table 3** are listed all the recovered species, with indication of paleoclimatic meaning (**PM**), frequency (**n**), bathymetric level (**P**), substrate (**S**), biocoenosis (**B**), habitus (**H**), trophism (**T**) and stratigrafic distribution (**DS**). The references to figures in Bellagamba & al. (2013) and in Bellagamba & Micali (2016) are also indicated (**Figs**). The last two digits indicate the year of published work: “13” for 2013 and “16” for 2016.  
In **Tab. 3** sono elencate tutte le specie rinvenute, con relativo significato paleoclimatico (**PM**) frequenza (**n**), piano batimetrico (**P**), substrato (**S**), biocenosi (**B**), habitus (**H**), trofismo (**T**) e distribuzione stratigrafica (**DS**). Vengono inoltre indicate le riproduzioni fotografiche (**Figs**) già riportate in Bellagamba & al. (2013) ed in Bellagamba & Micali (2016). Le ultime due cifre indicano l’anno di pubblicazione: “13” per 2013 e “16” per 2016.

Polyplacophora	PM	n	P	S	B	H	T	DS	Figs
<i>Lepthochiton cancellatus</i> (Sowerby, 1840)	W	RR	I prof- C	FSD		e-ss	O	M-Ol	
<b>Gastropoda</b>									
<i>Clanculus</i> sp.	W	RR				e-v	E		
<i>Clelandella miliaris</i> (Brocchi, 1814)	E	1	Iprof-B	FDc		e-v	CR	M-Ol	
<i>Gibbula</i> sp.	W	RR				e-v	O		
+ <i>Paroxystele patulum</i> (Brocchi, 1814)	W	RM-1	I-C	S		e-v	E	M-Pleis	
<i>Callumbonella</i> sp. (1)	W	RR	C			e-v	CR		
+ <i>Calliostoma sayanus</i> (Seguenza G., 1876)	W	RM-1	B	FS		e-v	CR	Pl-Pleis	
+ <i>Skenea</i> cf. <i>bogii</i> Chirli, 2004		1	I	F		e-v	DT	Pl	
<i>Skenea</i> sp.		1				e-v	DT		
<i>Tricolia pullus</i> (Linnaeus, 1758)	W	1	m-I-C	FSRD		e-v	E	Pl-Ol	
+ <i>Cerithium crenatum</i> (Brocchi, 1814)	W	RM	I	SFc		e-v	DT	M-Pleis	
<i>Cerithium</i> sp.?	W	RR				e-v	DT		
<i>Bittium latreillii</i> (Payraudeau, 1826)		RR	m-C	FSR		e-v	DT	Pl-Ol	
<i>B. submammillatum</i> (De Rayneval & Ponzi, 1854) (2)	E	C	I-C-B	DFS	PrDC PrDE	e-v	DT	Pl-Ol	
+ <i>Turritella tornata</i> (Brocchi, 1814)		RM	C	FS		i-v	DP	M-Pleis	
+ <i>T. tricarinata tricarinata</i> (Brocchi, 1814)	E	FF	I-C	FSD		i-v	DP	M-Pleis	



+ <i>T. vermicularis</i> (Brocchi, 1814)	W	1	I-C	SF		i-v	DP	M-Pleis	
<i>Alvania cancellata</i> (da Costa, 1779)	E	RM-1	m-C	FSD		e-v	DT	M-Ol	
<i>A.cf.pagodula</i> (Bucquoy, Dautzenberg & Dollfus, 1884)		1	m-C	FSRDc		e-v	DT	Pl-Ol	
<i>Obtusella intersecta</i> (Wood, 1857)		RR	I-C	S		e-v	DT	Pl-Ol	
<i>Pusillina inconspicua</i> (Alder, 1844)	E	R	I-C	DFS	PrHP PrAP	e-v	DT	Pl-Ol	2A, B-13
+ <i>P. sulzeriana</i> (Risso, 1826)		1	I	FSR		e-v	DT	M-Pleis	
<i>Hyala vitrea</i> (Montagu, 1803)	E	RR	I-B	FSD		e-v	DT	Pl-Ol	
+ <i>Tornus excalliferus</i> (Sacco, 1896)		RM-1	I-C	FSR		e-v	E	Msup- Pleis inf	
<i>Aporrhais pespelecani</i> (Linnaeus, 1758)	E	F	I-C	SFD	PrDc PrVTC	s-v	DT	M-Ol	
+ <i>A. uttingeriana</i> (Risso, 1826)	W	RM-2	I-C	FSD	PrDc	s-v	DT	M-Pleis	
<i>Crepidula moulinsii</i> Michaud, 1829	W	RM-1	I-C	RD		e-v	SP	M-Ol	
<i>Calyptraea chinensis</i> (Linnaeus, 1758)	W	F	I-C	RSF		e-v	SP	Olig-Ol	
+ <i>Xenophora infundibulum</i> (Brocchi, 1814)	W	RM-1	I	S		e-v	CR	M- Pleis inf	
<i>Petalconchus glomeratus</i> (Linnaeus, 1758)	W	RM	I-C	RDSF		e-ss	O	M-Ol	
+ <i>Cochlis plicatula</i> (Bronn, 1831)	W	RM-1	IC	SF		i-v	CR	M-Pl	
+ <i>C. raropunctata raropunctata</i> (Sasso, 1827)	W	RM+19	I-C	FS		i-v	CR	M-Pleis	
+ <i>Tectonatica tectula</i> Sacco, 1891		FF	I-C-B	FSD		i-v	CR	M-Pleis	
<i>Euspira macilenta</i> (Philippi, 1844)		FF	I-Csup	FS		i-v	CR	Pl-Ol	
+ <i>Neverita josephinia</i> Risso, 1826	W	R	I-C	SF	ExclSFBC	i-v	CR	Olig-Pleis inf	
+ <i>Sinum striatus</i> (de Serres, 1829)	W	RR	I-C	FS		i-v	CR	M-Pleis inf	
Naticidae		RR				i-v	CR		
Naticidae juv.		1				i-v	CR		
+ <i>Ficus subintermedia</i> (d'Orbigny, 1852)	W	RM+1	I-C	SFc		i-v	CR	M-Pleis inf	
<i>Semicassis saburon</i> (Bruguière, 1792)	W	RM	I-B	FSc	PrVB	i-v	CR	M-Ol	
Triphoridae		1				e-v	P		
<i>Aclis ascaris</i> (Turton, 1819)	E	RR	I-C	S		i-v	P	Pl-Ol	
<i>Epitonium algerianum</i> (Weinkauff, 1866)	E	RR	C-B	DFS		e-v	P	Pl-Ol	
<i>E. clathrus</i> (Linnaeus, 1758)	W	F	m-C	FSD		e-v	P	M-Ol	
+ <i>E. mesogonium</i> (Brugnone, 1876)	W	RM-1	I-C	FS		e-v	P	M-Pleis	
<i>Epitonium</i> spp.	W	RR				e-v	P		
+ <i>Gyroscala pseudoscalare</i> (Brocchi, 1814)	W	RM-1+1	I	F		e-v	P	M-Pleis	
<i>Eccliseogyra</i> sp.	W	1				e-v	P		
+ <i>Eulima boucheti</i> Landau, La Perna & Marquet, 2006	W	F	I-C	FS	PrVTC	e-v	P	P-Pleis inf	
<i>Campyloraphion</i> sp.		RM-1				e-v	P		
<i>Melanella</i> sp. 1		RR				e-v	P		
<i>Melanella</i> sp. 2		RM-1				e-v	P		
+ <i>Niso eburnea</i> Risso, 1826	W	RM-1	I-C	SFD		e-v	P	M-Pleis	
+ <i>Bolinus brandaris torularius</i> (Lamarck, 1822)	W	RR	I-C	FSD		e-v	CR	M-Pleis inf	
<i>Hexaplex trunculus</i> (Linnaeus, 1758)	W	RM	I-C	SFD		e-v	CR	M-Ol	
+ <i>Heteropurpura polymorpha</i> (Brocchi, 1814)	W	RM+14	I-C	FSD		e-v	CR	M-Pleis	
<i>Fusinus rostratus</i> (Olivi, 1792)	W	RM-1+1	I-B	FSD	PrVB	i-v	CR	M-Ol	
+ <i>Nassarius asperatus</i> (Cocconi, 1873)		RR	I-C	FSD		i-sd	N	M-Pleis	
+ <i>N. cantrainei</i> (Bellardi, 1882)		RM-2	C	SF		i-sd	N	Pl-Pleis inf	
+ <i>N. catulloi</i> (Bellardi, 1882)	E	R	C	FS		i-sd	N	M-Pleis inf	
+ <i>N. clathratus</i> (Born, 1778)	W	C	I-epiB	SF		i-sd	N	M-Pleis	
+ <i>N. crebricostulatus</i> (Bellardi, 1882)		F	I-C	FS		i-sd	N	Pl-Pleis inf	
+ <i>N. emilianus</i> (Mayer, 1872)		RM-4	C	SF		i-sd	N	Pl-Pleis inf	
+ <i>N. cf. longoastensis</i> (Sacco, 1890)		RM-1+1	I	S		i-sd	N	Pl-Pleis inf	
+ <i>N. musivus</i> (Brocchi, 1814)	W	RR	I-C	FS		i-sd	N	M-Pleis	
+ <i>N. planicostatus</i> (Bellardi, 1882)	W	1	I	SF		i-sd	N	M-Pleis	
+ <i>N. semistriatus</i> (Brocchi, 1814)	W	C	I-C-B	FSD		i-sd	N	M-Pleis	
+ <i>N. serraticosta</i> (Bronn, 1831)		RM-1	I-C	SF	PrSFBC	i-sd	N	M-Pleis	
<i>Nassarius</i> spp.		RR				i-sd	N		
<i>Tritia elata</i> Gould, 1855		1	I-C	FSD		i-sd	N	Pl-Ol	
<i>T. gibbosula</i> (Linnaeus, 1758)	W	RM-2	I	S		i-sd	N	M-Ol	



<i>T. cf. mutabilis</i> (Linnaeus, 1758)	W	RM-1	I	S	ExclSFBC	i-sd	N	M-Ol	
<i>T. pygmaea</i> (Lamarck, 1822)	E	RM-1	I	S	PrSFBC	i-sd	N	Pl-Ol	
+ <i>Demoulia conglobata</i> (Brocchi, 1814)	W	1	I	cFS		i-sd	N	M-Pleis inf	
+ <i>Cyllene paulucciana</i> (D’Ancona, 1864)	W	1	I	SF		i-sd	N	Pl	
+ <i>C. subumbilicata</i> (Bellardi, 1882)	W	RM-1+1				i-sd	N	M-Pl	
+ <i>Cancilla scrobiculata</i> (Brocchi, 1814)	W	RM-1	I-B	F		s-v	CR	M-Pleis	
+ <i>C. sismondai</i> (Michelotti, 1847)		RM-1	C	SF		s-v	CR	M-Pl	
+ <i>Sveltia varicosa</i> (Brocchi, 1814)	W	RM	I-C	FS		i-v	O	M-Pleis	
+ <i>Solatia hirta</i> (Brocchi, 1814)	W	RM	I-C	SF		i-v	O	M-Pleis	
+ <i>Conilithes antidiluvianus</i> (Bruguière, 1792)	W	RM	I-C	FSDR	PrVTC	i-v	CR	M-Pl	
+ <i>Conus betulinoides</i> juv. Lamarck, 1810	W	RM-1	I prof	SF		i-v	CR	M-Pl sup	
+ <i>C. brocchii</i> Bronn, 1826	W	RM-1	I-C	FS		i-v	CR	M-Pleis inf	
<i>Conus</i> sp.juv.	W	1				i-v	CR		2C, D-13
+ <i>Bathytoma cataphracta</i> (Brocchi, 1814)	W	RM+1	I-C-epiB	FSD		i-v	CR	Olig-Pl sup	
+ <i>Unedogemmula contigua</i> (Brocchi, 1814)	W	RM	I- C-B	FSD		s-v	CR	M-Pleis	
+ <i>Crassopleura sigmoidea</i> (Bronn, 1831)	W	RR	C-epiB	SFD		i-v	CR	M-Pleis	
<i>Sorgenfreispira brachystoma</i> (Philippi, 1844) (3)	E	F	I-C	SFc	PrDC PrDE	e-v	CR	M-Ol	
+ <i>Bela detexta</i> (Bellardi, 1877)		1	C	FS		e-v	CR	Pl-Pleis inf	
+ <i>B. hispidula</i> (Jan in Bellardi, 1847)	W	RR	I-C-B	FS		e-v	CR	M-Pleis	
+ <i>B. nitida</i> Pavia, 1976		F	C-B	FS	PrVTC	i-v	CR	M-Pl sup	2E, F-13
+ <i>B. vulpecula</i> _(Brocchi, 1814)	W	RR	I-B	FSD		e-v	CR	M-Pleis	
<i>B. zonata</i> _(Locard, 1892) (4)	E	RR	I-C	FS		e-v	CR	Pl-Ol	
<i>Mangelia attenuata</i> (Montagu, 1803)	E	1	I-C	SFD	ExclSFBC	e-v	CR	M-Ol	
<i>M. cf. costata</i> (Pennant, 1777)	E	RR	I-B	FSD		e-v	CR	Pl-Ol	
<i>M. cf. payraudeauti</i> (Deshayes, 1835)	W	RR	I-C	S		e-v	CR	Pl-Ol	
<i>M. unifasciata</i> (Deshayes, 1835)	E	RR	I-C	SFR		e-v	CR	M-Ol	
<i>Mangelia</i> sp. 1		1				e-v	CR		
<i>Mangelia</i> sp. 2		RR				e-v	CR		
+ <i>Smithiella ambigua</i> (Brugnone, 1862)		RR	I-C	SFD		e-v	CR	Pl	
<i>Raphitoma echinata</i> (Brocchi, 1814)		RR	I-C	SFDc		e-v	CR	M-Ol	
+ <i>Leufroyia raynevali</i> (Bellardi, 1877)		RR	I-C	FS		e-v	CR	M-Pleis	
+ <i>Terebra acuminata</i> Borson, 1820	W	RM	I-C	SFD		i-v	CR	M-Pl	
<i>T. reticularis</i> (Pecchioli in Sacco, 1891)	W	RM+3	I	S	PrSFBC	i-v	CR	M-Ol	
+ <i>Strioterebrum postneglectum</i> (Sacco, 1891)	W	RM	I-C	S		i-v	CR	M-Pleis inf	
+ <i>Subula fuscata</i> (Brocchi, 1814)	W	RM	I-C	SF	PrSFBC	i-v	CR	M-Pl	
+ <i>Basisulcata simplex</i> (Bronn, 1831)	W	RM	I-C	SFR		e-sd	CR	M-Pleis inf	
+ <i>Pseudomalaxis aldrovandii</i> (Foresti, 1868)	W	RR	C-B	FSD		e-sd	CR	Pl-Pleis inf	2G-13
<i>Mathilda</i> sp.		RM-1	C-B	FD		e-sd	CR		
<i>Odostomia acuta</i> Jeffreys, 1848	E	F	I-C	FS		e-sd	P	M-Ol	3A-16
<i>O. lukisii</i> Jeffreys, 1859	E	RR	I-B	FS		e-sd	P	Pl-Ol	3B, C-16
+ <i>O. perturrita</i> (Fekih, 1969)	W	1		FS		e-sd	P	Pl	3D, E-16
<i>Brachystomia eulimoides</i> (Hanley, 1844)	E	RM-1+1	I-C	FS		e-sd	P	Pl-Ol	3F, G-16
<i>Liostomia clavula</i> (Lovén, 1846)	E	R	C-B	F		e-sd	P	Pl-Ol	3H, I-16
<i>Megastomia alungata</i> (Nordsieck, 1972)	E	RR	C	DF		e-sd	P	Pl-Ol	3J, K-16
<i>M. conoidea</i> (Brocchi, 1814)	E	F	I-B	FS		e-sd	P	M-Ol	3L-16
<i>Noemiamea dolioliformis</i> (Jeffreys, 1848)	E	RR	I-C	FD		e-sd	P	Pl-Ol	3M, N-16
<i>Noemiamea</i> sp.		RR				e-sd	P		3O, P-16
<i>Euparthenia</i> sp. (5)		1	I-C			e-sd	P		3Q, R-16
+ <i>Ondina</i> cf. <i>cerullii</i> (Cossmann, 1921)		1		FS		e-sd	P	Pl-Pleis	
+ <i>Kongsrudia subtypica</i> (Sacco, 1892) (6)		R	C-B	SF		e-sd	P	M-Pl	3S, T-16
+ <i>Parthenina curvicostata</i> (Wood, 1848)	W	RR		FS		e-sd	P	M-Pl	3U,V-16
+ <i>Turbonilla intuspersulcata</i> Sacco, 1892		RR	I-C	SF		e-sd	P	Pl	4A-C-16
+ <i>T. lancae</i> (Libassi, 1859)		1		SF		e-sd	P	M-Pleis	4D, E-16
+ <i>T. plicatulasenensis</i> Sacco, 1892		1		SF		e-sd	P	Pl	4F, G-16



+ <i>T. pliocostellatoides</i> Sacco, 1892	W	F	I	FS		e-sd	P	Pl	4H, I-16
+ <i>T. pliopupoides</i> (Sacco, 1892)		RR	C	FS		e-sd	P	Pl	4J, K-16
<i>T. cf. postacuticostata</i> Sacco, 1892	W	R	I-C	FD		e-sd	P	Pl-Ol	4L, M-16
+ <i>T. subalpina</i> Sacco, 1892		1		SF		e-sd	P	Pl	4N, O-16
<i>Turbonilla</i> sp. 1		RR				e-sd	P		4P, Q-16
<i>Turbonilla</i> sp. 2 (n. sp.?)		1				e-sd	P		4R, S-16
<i>Pyrgiscus rufus</i> (Philippi, 1836)	E	RR	I-B	SFD		e-sd	P	M-Ol	4T, U-16
+ <i>P. rufus amplisuturatus</i> (Sacco, 1892)	E	RR	I-B (?)	SFD(?)		e-sd	P	Pl	4V, W-16
<i>Eulimella. acicula</i> (Philippi, 1836)	E	R	I-B	FSD		e-sd	P	M-Ol	5A, B-16
+ <i>E. persuturatoturris</i> Sacco, 1892		RR	I-C	SF		e-sd	P	M-Pl	5C, D-16
+ <i>E. pyramidata</i> (Deshayes, 1835)		RR	I-C	SF		e-sd	P	M-Pleis	5E, F-16
<i>E. scillae</i> (Scacchi, 1835)	E	RR	C-B	FSRD		e-sd	P	M-Ol	5G, H-16
+ <i>E. subalpina</i> Sacco, 1892		RR	C-B	SF		e-sd	P	Pl	5 I -16
<i>E. subcylindrata</i> (Dunker in Weinkauff, 1862)		RR	I-C	FS		e-sd	P	Pl-Ol	5J, K-16
<i>Eulimella</i> sp.		RR	C			e-sd	P		5L, M-16
+ <i>Acteon semistriatus</i> (Férussac, 1822)	E	FF	I-C	SF	PrSFBC	i-v	CR	?M-Pleis?	2X, Y-13
<i>Acteon</i> sp.		1				i-v	CR		
<i>Retusa nitidula</i> (Lovén, 1846)		RM-1+1	C-B	D		i-v	CR	Pl-Ol	
+ <i>R. pliosimplex</i> (Sacco, 1897)		RR		SF		i-v	CR	Pl	3A, B-13
<i>R. truncatula</i> (Bruguière, 1792)	E	F	I-C	FSD		i-v	CR	M-Ol	
<i>R. umbilicata</i> (Montagu, 1803)	E	1	I-C	FSRD		i-v	CR	M-Ol	
<i>Retusa</i> sp.		RR				i-v	CR		
<i>Pyrunculus</i> sp.		1				i-v	CR		
<i>Volvoulella acuminata</i> (Bruguière, 1792)	E	R	I-C	SFD		i-v	CR	M-Ol	
<i>Ringicula auriculata</i> (Ménard de La Groye, 1811)	W	C	I-B	FSD		i-v	P	M-Ol	
+ <i>Atys pliocrassa</i> (Sacco, 1897)		R	C	SF		i-v	CR	Pl	
<i>Atys</i> sp.		RM-1+1				i-v	CR		
<i>Bulla striata</i> Bruguière, 1792	E	RM-1	m-I	SFR		i-v	CR	M-Ol	
<i>Hermania scabra</i> (Müller, 1784)	E	R	I-B	FSD		i-v	CR	M-Ol	3 C-13
<i>Roxania utriculus</i> (Brocchi, 1814)	E	F	I-epiB	DSF	PrDC	i-v	CR	M-Ol	
<i>Cylichna cylindracea</i> (Pernant, 1777)	E	F	I-epiB	FSD		i-v	CR	M-Ol	
<i>Acteocina knockeri</i> (Smith, 1872)	W	F	I	S		i-v	CR	M-Ol	3D-F-13
<i>Scaphander lignarius</i> (Linnaeus, 1758)	E	F	I-B	FSD		i-v	CR	M-Ol	
<i>Cephalaspidea</i>		1				i-v	CR		
<i>Cavolinia tridentata</i> (Niebuhr, 1775 ex Forsskål)	E	1				p		Pl-Ol	
<i>Diacria trispinosa</i> (Blainville, 1821)	W	RR				p		Pl-Ol	
<i>Clio pyramidata</i> Linné, 1767	W	RR				p		M-Ol	
<i>Styliola subula</i> (Quoy & Gaimard, 1827)	W	1				p		M-Ol	
<b>Bivalvia</b>									
+ <i>Nucula jeffreysi</i> Bellardi, 1875		C	I	S		s-sd	DT	Pl	
<i>N. nitidosa</i> Winckworth, 1930 (7)	E	C	I-C	FSD		s-v	DT	M-Ol	
<i>Saccella commutata</i> (Philippi, 1844)	W	CC	I-C-B	DSF	PrDE PrDC	s-v/ sd	DT	M-Ol	
<i>Lembulus pellus</i> (Linné, 1767)	W	CC	I-B	SFD		s-sd	DT	M-Ol	
+ <i>Yoldia nitida</i> (Brocchi, 1814)		F	I-C	FD	PrVTC	s-sd	DT	M-Pleis	
<i>Malletia</i> sp.		RR				s-sd	DT		
<i>Arca tetragona</i> Poli, 1795	E	1	I-B	DFS	PrDC	sb	f	M-Ol	
+ <i>Ambrogia mytiloides</i> (Brocchi, 1814)		F	I-C	FS		sb	f	M-Pleis	
<i>Anadara gibbosa</i> (Reeve, 1844) (8)	W	C	I-C-B	FD	PrDC PrVTC	sb	f	Olig-Ol	
<i>Striarca</i> sp.		1					f		
<i>Glycymeris nummaria</i> (Linnaeus, 1758)	W	RM+7	I-C	SFD	ExclSFBC	s-sd	f	M-Ol	
<i>Musculus cf. costulatus</i> (Risso, 1826)		RR	I-B	DRFS		eb	f	Pl-Ol	
<i>M. cf. discors</i> (Linné, 1767)	E	C	m-C	FSD		eb	f	Pl-Ol	3G, H-13
+ <i>Modiolus longus</i> (Bronn, 1831)		RM				eb	f	Pl	
<i>Atrina pectinata</i> (Linné, 1767)	W	RM	I-B	FSD		sb	f	M-Ol	
+ <i>Pteria phalenacea</i> (Lamarck, 1819)	W	R	I-B	FS	ExclVTC	eb	f	M-Pleis inf	3I, J-13



+ <i>Pecten bosniasckii</i> DeStefani & Pantanelli, 1878		RM	I	S		e-v	f	Pl	
+ <i>Pecten flabelliformis</i> (Brocchi, 1814)	W	RM-2	I-C	FSD	ExclSGCF	e-v	f	M-Pleis inf	
+ <i>P. flabelliformis persulculata</i> (Sacco, 1897)		RM		FS		e-v	f	M-Pl	
<i>P. jacobaeus</i> juv. (Linnaeus, 1758)	W	RM-1+1	I-B	DFS	ExclDC	e-v	f	Pl-Ol	
<i>Aequipecten opercularis</i> (Linnaeus, 1758)	E	RM	I-B	FSD	PrDC	e-v	f	M-Ol	
<i>Mimachlamys varia</i> (Linnaeus, 1758)	W	FF	I-C	DRFS	PrDC	eb	f	M-Ol	
+ <i>Amusium cristatum</i> (Bronn, 1827)	W	C	I-C-B	FSD		e-v	f	M-Pleis	
<i>Cyclopecten hoskynsi</i> (Forbes, 1844)	E	1	C-B	FD	PrVB	e-v	f	Pl-Ol	
Pectinidae		1				e-v	f		
<i>Anomia ephippium</i> Linnaeus, 1758	W	FF	I-B	RD	PrDC	e-ss	f	M-Ol	
<i>Limatula subauriculata</i> (Montagu, 1808)	E	R	I-B	FSD	PrVB	eb	f	M-Ol	3K, L-13
Limidae		1				eb	f		
+ <i>Cubitostrea frondosa</i> (de Serres, 1829)		RM-1	I	R		e-ss	f	M-Pl	
<i>Ostrea edulis</i> Linnaeus, 1758	E	RM+4	m-C	R		e-ss	f	M-Ol	
+ <i>Lucina orbicularis</i> Deshayes, 1836		RR	I	FS		i-sd	f	M- Pleis inf	
<i>Lucinella divaricata</i> (Linnaeus, 1758)	W	FF	I-C	SD	PrSFBC	i-sd	f	M-Ol	
<i>Vasconiella</i> cf. <i>jeffreysiana</i> (Fischer, 1873)	W	1	I-C			i-sd	P	Pl-Ol	
<i>Pseudopythina macandrewi</i> (Fischer, 1867)		1	C	FS		i-sd	f	Pl-Ol	
<i>Bornia</i> sp.		RM-1				i-sd	f		
<i>Mysella</i> sp.		RR				i-sd	P		3M, N-13
+ <i>Glans intermedia</i> (Brocchi, 1814)	W	RM	I-C	FS		s-sd	f	M-Pleis	
<i>Procardium indicum</i> (Lamarck, 1819)	W	RM+1	I-C	SFD		s-sd	f	M-Ol	
<i>Cardium</i> sp.	W	1				s-sd	f		
<i>Cardium</i> sp.?	W	RR				s-sd	f		
<i>Acanthocardia aculeata</i> (Linnaeus, 1758)	E	FF	I	SFD	PrSFBC	s-sd	f	M-Ol	
<i>A. echinata</i> (Linnaeus, 1758)	W	CC	I-C-B	DSF	PrDE	s-sd	f	M-Ol	
<i>A. spinosa</i> (Solander, 1786)	W	RM-1	I-C	SFD		s-sd	f	Pl-Ol	
<i>Acanthocardia</i> sp.		RR				s-sd	f		
<i>Parvicardium minimum</i> (Philippi, 1836)	E	1	I-C-B	DSF	PrDC PrDE	s-sd	f	M-Ol	
<i>P. scabrum</i> (Philippi, 1844)	E	F	I-B	DFS		s-sd	f	M-Ol	3Q, R-13
+ <i>P. vroomi pliopapillosa</i> (Sacco, 1899)	W	RR	I-C	R		s-sd	f	Pl sup	3O, P-13
<i>Parvicardium</i> sp.		1				s-sd	f		
+ <i>Laevicardium subturgidum millasiense</i> (Fontannes, 1881)	W	R	C	FS		s-sd	f	M-Pleis	3S, T-13
<i>Cerastoderma glaucum</i> (Bruguière, 1789)	E	1	m-I	FS		s-sd	f	M-Ol	
Cardiidae		1				s-sd	f		
<i>Mactra</i> sp.		1				i-sd	f		
<i>Spisula subtruncata</i> (da Costa, 1778)	E	CC	I-C	SF	PrSFBC	i-sd	f	M-Ol	
<i>Lutraria angustior</i> _Philippi, 1844	W	C	m-C	FD		i-sd	f	Pl-Ol	
<i>Donacilla cornea</i> (Poli, 1791)	W	F	I	SF		i-sd	f	M-Ol	3U,V-13
<i>Ervilia castanea</i> (Montagu, 1803) (9)	W	F	I-B	DF		i-sd	f	Pl-Ol	
<i>Solen marginatus</i> Pulteney, 1799 (10)	E	F	m-I	SF	ExclSFBC	i-sd	f	M-Ol	
<i>Phaxas pellucidus</i> (Pennant, 1777)	E	FF	I-C	DSF		i-sd	f	Pl-Ol	
<i>Oudardia compressa</i> (Brocchi, 1814)	W	CC	I-C	DFS	ExclDC	i-sd	DP	M-Ol	
<i>Moerella pulchella</i> (Lamarck, 1818)	W	C	m-I	SF	ExclSFBC	i-sd	DP	M-Ol	
<u><i>Donax</i> cf. <i>trunculus</i></u> Linnaeus, 1758	W	1	m-I	S	ExclSFS	i-sd	DP	Pl-Ol	
<i>D. venustus</i> Poli, 1795	W	RR	I	SF	ExclSFBC/ SFHN	i-sd	DP	Pl-Ol	
<i>Donax</i> sp.	W	1				i-sd	DP		
<i>Gari</i> cf. <i>depressa</i> (Pennant, 1777)	E	F	I	SFD		i-sd	DP	Pl-Ol	
<i>G. fervensis</i> (Gmelin, 1791)	E	FF	I-C	DSF	ExclDC	i-sd	DP	M-Ol	
+ <i>G. cf. uniradiata</i> (Brocchi, 1814)		F	I-C	SFD		i-sd	DP	M-Pleis inf	
<i>Abra alba</i> (Wood, 1802)	E	FF	I-C	FSD		i-sd	DP	M-Ol	
<i>A. prismatica</i> (Montagu, 1808)	E	F	I-B	DSF	PrDC	i-sd	DP	M-Ol	
<i>Abra</i> sp. 1		RR				i-sd	DP		
<i>Abra</i> sp. 2		F				i-sd	DP		
<i>Azorinus chamasolen</i> (da Costa, 1778)	E	RR	I-B	DSF	PrDC PrDE	i-sd	DP	M-Ol	

<i>Glossus humanus</i> (Linnaeus, 1758)	E	RM	I-C	DSF	PrDC PrDE	i-sd	f	M-Ol	
+ <i>Circomphalus foliaceolamellosus</i> (Dillwyn, 1817)	W	CC	I	S	PrSFBC	i-sd	f	M-Pl sup	
<i>Venus nux</i> Gmelin, 1791	W	C	I-B	FSD	PrVTC	i-sd	f	M-Ol	
<i>Chamelea striatula</i> (da Costa, 1778)	E	FF	I-B	FS		i-sd	f	Pl-Ol	
<i>Timoclea ovata</i> (Pennant, 1777)	E	CC	I-C-B	DSF	PrDC PrDE	i-sd	f	M-Ol	
<i>Dosinia lupinus</i> (Linnaeus, 1758)	W	FF	I-C	SF	PrSFBC	i-sd	f	M-Ol	
<i>Dosinia</i> sp.		R				i-sd	f		
<i>Callista chione</i> (Linnaeus, 1758)	W	R	I-C	SFD		i-sd	f	M-Ol	
+ <i>Pelecypora gigas</i> (Lamarck, 1818)	W	RM	I	S	PrSFBC	i-sd	f	M-Pl sup	
+ <i>P. islandicoides</i> (Lamarck, 1818)	W	FF	I-C	SF		i-sd	f	M-Pleis inf	
<i>Polititapes aureus</i> (Gmelin, 1791)	E	R	I	SF	PrSVMC PrSFBC	i-sd	f	Pl-Ol	
<i>Ruditapes decussatus</i> (Linnaeus, 1758)	E	1	I	FS		i-sd	f	Pl-Ol	
<i>Irus irus</i> (Linnaeus, 1758)	W	RR	m-C	RDFS		ib	f	M-Ol	
<i>Petricola</i> sp.		1				i	f		
Veneridae		1				i	f		
<i>Corbula gibba</i> (Olivi, 1792)	E	CC	I-B	FSD		i-ss	f	Paleoc-Ol	
<i>Hiatella arctica</i> (Linné, 1767)	E	RR	m-B	RD		eb	f	Olig-Ol	
<i>Panopea glycymeris</i> (Born, 1778)	W	RM	I-C	SF		i-ss	f	M-Ol	
<i>Xylophaga dorsalis</i> (Turton, 1819)	E	RR	C-B			perf		M-Ol	4A, B-13
+ <i>Pecchiolia argentea</i> (Mariti, 1797)		1	C-B	FS		i-sd	CR	Pl	
<i>Cuspidaria cuspidata</i> (Olivi, 1792)	E	RR	C-B	DFS	PrDC PrDE	i-sd	CR	M-Ol	4C, D-13
<i>C. rostrata</i> (Spengler, 1793)	E	RM-1+1	C-B	DFS	PrDL	i-sd	CR	Pl-Ol	
<i>Cardiomya costellata</i> (Deshayes, 1835)	W	RR	C-B	DFS	ExclDC	i-sd	CR	Pl-Ol	
Scaphopoda									
+ <i>Omniglypta jani</i> (Hörnes, 1856)	W	RM	C	SF		i-sd	DP	M-Pl	
+ <i>Antalis fossile</i> (Gmelin, 1791)	W	RM	I	S		i-sd	DP	M-Pleis inf.	
+ <i>A. raricostatum</i> (Sacco, 1897)		RM		SF		i-sd	DP	M-Pleis inf.	
+ <i>Paradentalium sexangulum</i> (Gmelin, 1791)	W	RM+14	I-C	SF	PrSFBC	i-sd	DP	M-Pleis	4E, F-13
<i>Fustiaria rubescens</i> (Deshayes, 1825)	W	FF	I-B	FSD		i-sd	DP	M-Ol	4G-I-13

**Tab. 3.** + = species disappeared from Mediterranean Sea. Paleoclimatic meaning (**PM**): W = taxon of warm, subtropical and tropical waters; E = eur-  
ythermal taxon. Frequency (**n**): RM = hand-picked species; RM-n = hand-picked species, plus number of specimens; RM + n = hand-picked species,  
plus number of specimens present in the sub-samples; RM-n + n' = hand-picked species with number of specimens, plus number of specimens  
present in the sub-samples; RR = >1, < 7; R = > 7, < 14; F = > 14, < 40; FF = > 40, < 100; C = > 100, < 300; CC = > 300. Zone (**P**): m = mediolit-  
toral; I = infralittoral; **I** = mainly infralittoral; C = circalittoral; **C** = mainly circalittoral; B = bathyal. Substrate (**S**): S = sand; **S** = mainly sandy; F = mud;  
**F** = mainly muddy; D = detritic; R = rocky; c = coralligenous. Biocoenosis (**B**): SFHN = fine sands in shallow waters; SFBC = well-sorted fine sands; SFS  
= shallow water fine sands; SVMC = muddy sands in sheltered waters; SGCF = coarse sands and gravels under the influence of bottom currents; AP  
= infralittoral algae; HP = *Posidonia oceanica* meadow; DC = coastal detritic bottom; DE = muddy detritic bottom; DL = shelf-edge detritic bottom;  
VTC = coastal terrigenous muds; VB = bathyal muds; Excl = exclusive species; Pr = preferential species. Habitus (**H**): e = epifaunal; s = semi-infaunal; i  
= infaunal; v = vagile; sd = sedentary; ss = sessile; eb = epibyssate; sb = semi-infaunale byssate; p = planktonic; perf = wood-borer. Trophism (**T**): O  
= omnivore; E = herbivore; DT = detritivore; DP = depositivore; SP = suspension feeder; CR = carnivorous; P = parasite; N = necrophagous; f = filter  
feeder. Stratigraphic distribution (**DS**): Paleoc = Paleocene; Olig = Oligocene; M = Miocene; Pl = Pliocene; Pleis = Pleistocene; Ol = Holocene.

**Tab. 3.** + = specie non più presente nel Mediterraneo. Significato paleoclimatico (**PM**): W = taxon indicativo di acque da temperate a tropicali; E =  
taxon euritermo. Frequenza (**n**): RM = specie raccolta manualmente; RM-n = specie raccolta manualmente con numero di esemplari; RM + n = specie  
raccolta manualmente + numero di esemplari presenti nei sotto-campioni; RM-n + n' = specie raccolta manualmente con numero di esemplari +  
numero di esemplari presenti nei sotto-campioni; RR = >1, < 7; R = > 7, < 14; F = > 14, < 40; FF = > 40, < 100; C = > 100, < 300; CC = > 300.  
Piano (**P**): m = mesolitorale; I = infralitorale; **I** = prevalente distribuzione nell'infralitorale; C = circalitorale; **C** = prevalente distribuzione nel circalitorale;  
B = batiale. Substrato (**S**): S = sabbioso; **S** = prevalente distribuzione in substrati sabbiosi; F = fangoso; **F** = prevalente distribuzione in substrati fan-  
gosi; D = detritico; R = roccioso; c = coralligeno. Biocenosi (**B**): SFHN = Sabbie Fini degli Alti Livelli; SFBC = Sabbie Fini Ben Classate; SFS = Sabbie Fini  
Superficiali; SVMC = Sabbie Fangose di Moda Calma; SGCF = Sabbie e Ghiaie sotto l'influenza di Correnti di Fondo; AP = Alghe Fotofile; HP = Prat-  
erie a Posidonia; DC = Detritico Costiero; DE = Detritico Infangato; DL = Detritico del Largo; VTC = Fanghi Terrigeni Costieri; VB = Fanghi Batiali;  
Excl = specie caratteristica esclusiva; Pr = specie caratteristica preferenziale. Habitus (**H**): e = epifaunale; s = seminafaunale; i = infaunale; v = vagile; sd  
= sedentaria; ss = sessile; eb = epibissata; sb = seminafaunale bissata; p = planctonica; perf = perforatrice legno. Trofismo (**T**): O = omnivora; E = er-  
bivora; DT = detritivora; DP = depositivora; SP = sospensivora; CR = carnivora; P = parassita; N = necrofaga; f = filtratrice. Distribuzione stratigrafica  
(**DS**): Paleoc = Paleocene; Olig = Oligocene; M = Miocene; Pl = Pliocene; Pleis = Pleistocene; Ol = Olocene.

The species marked with the below listed numeric notes were indicated in Bellagamba & al. (2013) with a different name. In particular:

- (1) - Trochidae
- (2) - *Bittium reticulatum* (da Costa, 1778)
- (3) - *Bela nebula* (Montagu, 1803)



- (4) - *Bela turgida* (Forbes in Reeve, 1844)  
(5)- *Chrysallida* sp.  
(6) - *Chrysallida stefanisi* (Jeffreys, 1869)  
(8) - *Anadara diluvii* (Lamarck, 1805)  
(9) - *Scrobicularia* cf. *plana* (da Costa, 1778).

In addition:

- (7) – In the number of *Nucula nitidosa* specimens was including 33 specimens of *N. jeffreysi*.  
(10) – In the number of *Solen marginatus* specimens was including 9 specimens of *Phaxas pellucidus*.

Lastly, the species indicated as *Neopycnodonte coclear* (Poli, 1795), obtained by the manual picking, shall be referred to *Ostrea edulis* Linnaeus, 1758.

Systematics

Class Polyplacophora Gray, 1821  
Family Leptochitonidae Dall, 1889  
Genus *Leptochiton* Gray, 1847  
***Leptochiton cancellatus* (Sowerby, 1840)**  
**(Fig. 1 A, B)**

*Chiton cancellatus* Sowerby II, 1840: figs. 104, 104 a-b, 105.  
*Lepidopleurus cancellatus* - Cossignani et al., 1992: fig. 002.  
*Lepidopleurus cancellatus* - Arduino et al., 1995: p. 9.  
*Lepidopleurus cancellatus* - Dell’Angelo et al., 2000: p. 146, fig. 5.  
*Lepidopleurus cancellatus* - Chirli, 2004: p. 5, tav. 1, figg. 16-18, tav. 2, figg. 1, 2.  
*Leptochiton cancellatus* - Sosso & Dell’Angelo, 2010: pp. 14, 16.  
*Leptochiton cancellatus* - Dell’Angelo et al., 2012: p. 54, fig. 3 A-C.

Remarks

The material consists of three intermediate valves, referred to this species for the granules longitudinally aligned. It was first reported for the Sicilian Pliocene by Dell’Angelo & al. (2012).

Classe Gastropoda Cuvier, 1797  
Family Trochidae Rafinesque, 1815  
Genus *Paroxystele* Schultz, 1969  
***Paroxystele patulum* (Brocchi, 1814)**  
**(Fig. 1 C-E)**

*Trochus patulus* Brocchi, 1814: p. 356, tav. V, figg. 19 a, b.  
*Oxystele patula* - Sacco, 1896b: p. 28, tav. III, figg. 28-31.  
*Diloma (Oxystele) patulum* - Malatesta, 1974: p. 167, tav. XIII, figg. 11 a, b.  
*Diloma (Oxystele) patulum* - Pavia, 1976: p. 123, tav. 1, figg. 10, 12; tav. 2, figg. 1 a-c.  
*Diloma (Paroxystele) patulum* - Pavia, 1980: p. 210, tav. 1, figg. 12, 13.  
*Diloma (Paroxystele) patulum* - Cavallo & Repetto, 1992: p. 40, fig. 034.  
*Diloma patulum* - Chirli, 2004: p. 77, tav. 32, figg. 5-9.  
*Diloma (Oxystele) patula* - Caprotti, 2011: p. 48, fig. 1 A, B.  
*Diloma patulum* - Chirli & Linse, 2011: p. 47, pl. 8, figg. 5 a-d.

Remarks

Lacking detailed studies, we refer to *P. patulum* s.l. the various morpha. The found specimen resembles the variety “*semisphaerica*” of Sacco (1896b).

Family Calliostomatidae Thiele, 1924  
Genus *Calliostoma* Swainson, 1840  
***Calliostoma sayanus* (Seguenza G., 1876)**  
**(Fig. 1 F)**

*Calliostoma sayanus* - Micali & Villari, 1986: p. 270, fig. 4.

Remarks

The found specimen is incomplete, referred to this species for the concavity of the whorls and the strong sub-sutural cord. Micali & Villari (1986) reported *C. sayanus* for the Pleistocene of Archi (Reggio Calabria), giving bibliographic references and original description. This species has never been reported in the Tosco-Emilian Pliocenic Basin.

Family Cerithiidae Fleming, 1822  
Genus *Bittium* Gray, 1847  
***Bittium latreillii* (Payraudeau, 1826)**  
**(Fig. 1 G, H)**

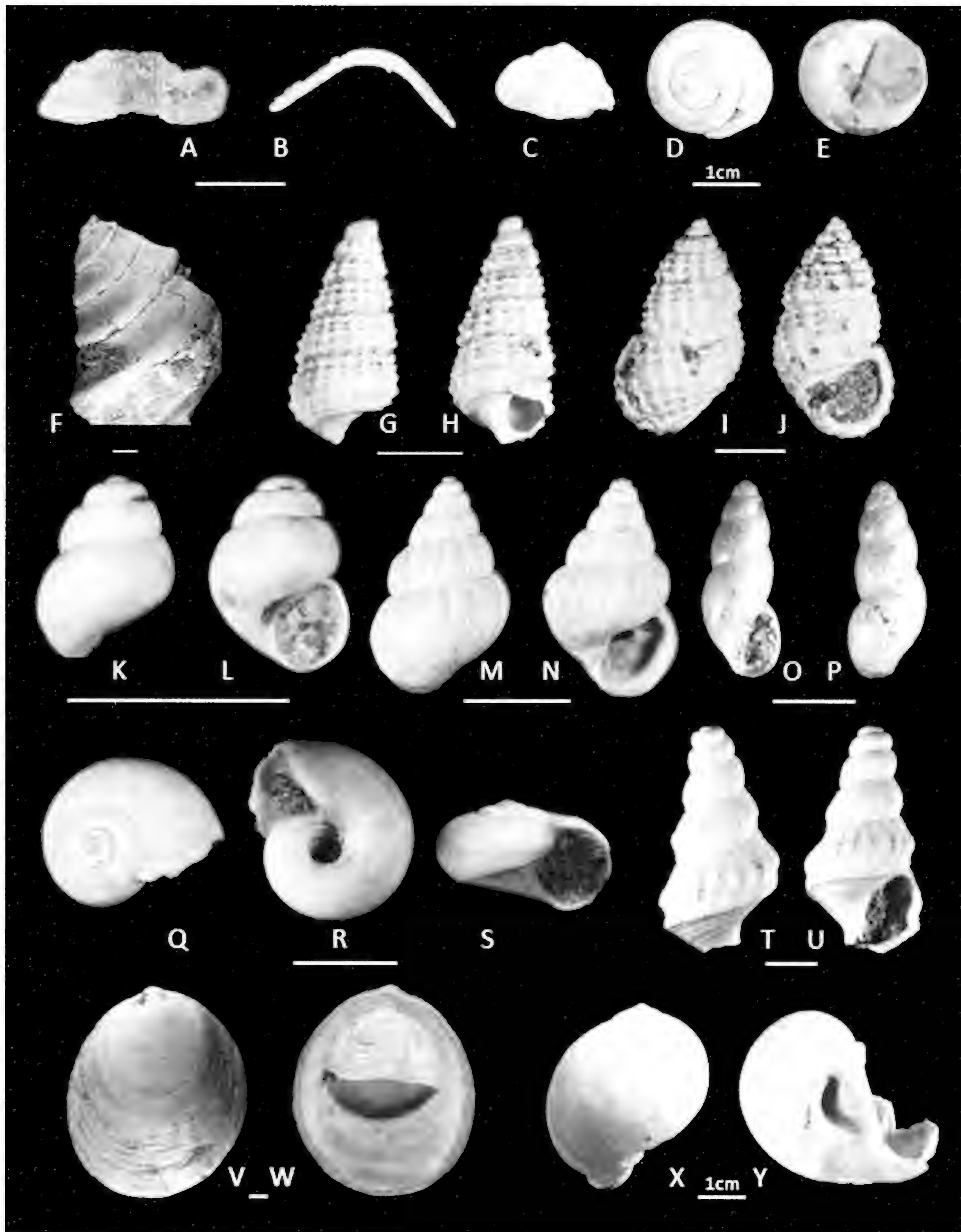
*Bittium latreillei* - Cavallo & Repetto, 1992: p. 46, fig. 054.  
*Bittium latreillii* - Cossignani et al., 1992: fig. 049.  
*Bittium latreillii* - Arduino et al., 1995: p. 28.  
*Bittium latreillii* - Giannuzzi Savelli et al., 1997: figg. 82-85.  
*Bittium latreilli* - Tisselli & Giunchi, 2005: pp. 15, 17, fig. 8.  
*Bittium latreillii* - Chirli, 2006: p. 91, tav. 37, figg. 1-5.

Remarks

The four specimens are referred to this species for the markedly conical general outline, with flat whorls, separated by deep suture. The peculiar sculpture is composed of spiral cords that cross the axial ribs forming tubercles.

Family Rissoidae Gray, 1847  
Genus *Alvania* Risso, 1826  
***Alvania cancellata* (da Costa, 1779)**  
**(Fig. 1 I, J)**

*Turbo cancellatus* da Costa, 1779: p. 104, tav. VIII, figg. 6, 9.  
*Acinopsis cancellata* - Sacco, 1895: p. 27.  
*Acinopsis cancellata* - Malatesta, 1974: p. 174, tav. XIII, fig. 16.  
*Alvania (Alvania) cancellata* - Cavallo & Repetto, 1992: p. 52, fig. 073.  
*Alvania (Alvania) cancellata* - Cossignani et al., 1992: fig. 064.  
*Alvania cancellata* - Arduino et al., 1995: p. 35.  
*Alvania (Alvania) cancellata* - Giannuzzi Savelli et al., 1997: figg. 398, 408 b.  
*Alvania cancellata* - Chirli, 2006: p. 13, tav. 5, figg. 12-16; tav. 6, figg. 1-4.  
*Alvania cancellata* - Chirli & Linse, 2011: p. 76, pl. 20, figg. 3 a-e.



**Fig. 1.** A, B. *Leptochiton cancellatus* (Sowerby, 1840). C-E. *Paroxystele patulum* (Brocchi, 1814). F. *Calliostoma sayanus* (Seguenza G., 1876). G, H. *Bittium latreillii* (Payraudeau, 1826). I, J. *Alvania cancellata* (da Costa, 1779). K, L. *Obtusella intersecta* (Wood S.W., 1857). M, N. *Pusillina sulzeriana* (Risso, 1826). O, P. *Hyala vitrea* (Montagu, 1803). Q-S. *Tornus excalliferus* (Sacco, 1896). T, U. *Aporrhais pespelecani* (Linnaeus, 1758). V, W. *Crepidula moulinsii* Michaud, 1829. X, Y. *Cochlis plicatula* (Bronn, 1831). Scale bars = 1 mm (where not otherwise indicated).

**Fig. 1.** A, B. *Leptochiton cancellatus* (Sowerby, 1840). C-E. *Paroxystele patulum* (Brocchi, 1814). F. *Calliostoma sayanus* (Seguenza G., 1876). G, H. *Bittium latreillii* (Payraudeau, 1826). I, J. *Alvania cancellata* (da Costa, 1779). K, L. *Obtusella intersecta* (Wood S.W., 1857). M, N. *Pusillina sulzeriana* (Risso, 1826). O, P. *Hyala vitrea* (Montagu, 1803). Q-S. *Tornus excalliferus* (Sacco, 1896). T, U. *Aporrhais pespelecani* (Linnaeus, 1758). V, W. *Crepidula moulinsii* Michaud, 1829. X, Y. *Cochlis plicatula* (Bronn, 1831). Barre di scala = 1 mm (ove non diversamente indicato).



## Remarks

This species is characterized by a strong sculpture with squared cancellation, the deep suture, the outer lip thickened, with internal denticles positioned in correspondence of spiral cords.

Genus *Obtusella* Cossmann, 1921  
*Obtusella intersecta* (Wood S.W., 1857)  
 (Fig. 1 K, L)

*Obtusella* cf. *intersecta* - Cavallo & Repetto, 1992: p. 54, fig. 081.  
*Obtusella intersecta* - Cossignani et al., 1992: fig. 075.  
*Obtusella intersecta* - Arduino et al., 1995: p. 42.  
*Obtusella intersecta* - Giannuzzi Savelli et al., 1997: fig. 297.

## Remarks

This species has been found in three specimens only in a sub-sample of the group B. The outline is very globose, with last whorl occupying about ¾ of the total height, the aperture is sub-circular, with a false umbilicus.

Genus *Pusillina* Monterosato, 1884  
*Pusillina sulzeriana* (Risso, 1826)  
 (Fig. 1 M, N)

*Alvania sulzeriana* Risso, 1826: p. 145, tav. IX, fig. 124.  
*Apicularia sulzeriana* - Sacco, 1895: p. 20, t. I, figg. 46-48.  
*Apicularia sulzeriana* - Malatesta, 1974: p. 176, tav. XIII, fig. 18.  
*Apicularia sulzeriana* - Pavia, 1976: p. 130, tav. 3, figg. 11, 17-23.  
*Rissoa sulzeriana* - Cavallo & Repetto, 1992: p. 50, fig. 071.  
*Pusillina sulzeriana* - Chirli, 2006: p. 49, tav. 22, figg. 8-12.  
*Pusillina sulzeriana* - Sosso & Dell'Angelo, 2010: pp. 22, 32.  
*Pusillina sulzeriana* - Chirli & Linse, 2011: p. 72, pl. 18, figg. 6 a-c.

## Remarks

This is a very variable species showing whorls of increasing convexity from the apex to the aperture. The sculpture consists of axial ribs more developed on the last whorl, but never remarkably crowded or strong. The examined specimen is similar to that figured by Pavia (1976) at figg. 17 and 22.

Family Iravadiidae Thiele, 1928  
 Genus *Hyala* Adams H. & Adams A., 1852  
*Hyala vitrea* (Montagu, 1803)  
 (Fig. 1 O, P)

*Turbo vitreus* Montagu, 1803: p. 321, tav. 12, fig. 3.  
*Hyala vitrea* - Sacco, 1895: p. 31.  
*Cingula (Hyala) vitrea* - Pavia, 1976: tav. 4, figg. 1 a, b.  
*Hyala vitrea* - Cavallo & Repetto, 1992: p. 56, fig. 095.  
*Hyala vitrea* - Cossignani et al., 1992: fig. 085.  
*Hyala vitrea* - Arduino et al., 1995: p. 49.  
*Hyala vitrea* - Bogi & Cauli, 1997: p. 134.  
*Hyalea vitrea* - Giannuzzi Savelli et al., 1997: figg. 549-551.  
*Hyala vitrea* - Chirli, 2006: p. 71, tav. 29, figg. 10-14.

*Hyala vitrea* - Sosso & Dell'Angelo, 2010: pp. 22, 33.  
*Hyala vitrea* - Chirli & Linse, 2011: p. 91, pl. 26, figg. 6 a-c.

## Remarks

This species has been found in two specimens. The shell is very fragile, hyaline, with a pupoid outline, convex whorls separated by well marked suture, the aperture is oval, adapically restricted. Bogi & Cauli (1997) report for the first time this species in the Pliocene of Tuscany.

Familia Tornidae Sacco, 1896  
 Genus *Tornus* Turton & Kingston, 1830  
*Tornus excalliferus* (Sacco, 1896)  
 (Fig. 1 Q-S)

*Collonia (?) excallifera* Sacco, 1896b: p. 8, tav. I, fig. 15 c.  
*Tornus (T.) excalliferus* - Pavia, 1976: p. 130, tav. 3, figg. 24-27.  
*Tornus excalliferus* - Cavallo & Repetto, 1992: p. 58, fig. 097.  
*Tornus excalliferus* - Chirli, 2006: p. 77, tav. 31, figg. 4-9.

## Remarks

The shell is very depressed, not sculptured, with whorls rapidly growing in width, the base is convex with a narrow carina, in the middle there is a wide circular umbilicus, surrounded by two small cords, separated by a groove. The aperture is sub-circular, lightly angulose for the presence of the carina.

Family Aporrhaidae Gray, 1850  
 Genus *Aporrhais* da Costa, 1778  
*Aporrhais pespelecani* (Linnaeus, 1758)  
 (Fig. 1 T, U)

*Strombus pes pelecani* Linnaeus, 1758: p. 742.  
*Chenopus pespelecani* - Sacco, 1893b: p. 28, tav. II, figg. 28-37.  
*Aporrhais pes pelecani* - Kobelt, 1908: p. 12, taf. CI, figg. 10-11; taf. CII-CIII.  
*Aporrhais pes pelecani* - Settepassi, 1971: p. I, tav. 1-8, 14.  
*Aporrhais (Aporrhais) pespelecani* - Malatesta, 1974: p. 215, tav. XVI, figg. 2 a-c.  
*Aporrhais pespelecani* - Rosso, 1979: pl. 15, figg. 5-6.  
*Aporrhais pes-pelecani* - Terreni, 1981: tav. III, fig. 3.  
*Aporrhais pespelecani* - Chirli, 1988: tav. III, fig. 1.  
*Aporrhais pespelecani* - Cavallo & Repetto, 1992: p. 60, fig. 102.  
*Aporrhais pespelecani* - Cossignani et al., 1992: fig. 087.  
*Aporrhais pespelecani* - Arduino et al., 1995: p. 50.  
*Aporrhais pespelecani* - Giannuzzi-Savelli et al., 1997: figg. 573-587.  
*Aporrhais pespelecani* - Chirli & Richard, 2008: p. 25, pl. 3, fig. 8.  
*Aporrhais pespelecani* - Scaperrotta et al., 2009: pp. 62, 156.  
*Aporrhais pespelecani* - Sosso & Dell'Angelo, 2010: pp. 23, 33.  
*Aporrhais pespelecani* - Chirli & Linse, 2011: p. 92, pl. 27, figg. 1 a-c.

## Remarks

This species was reported and figured by many authors, but juvenile specimens, very different from the adult ones, have never been figured. Among the above listed references, only Scaperrotta et al. (2009) figure two juven-

ile specimens. At “Le Conchiglie” have been manually collected some adult specimens, also present in the examined sub-samples, where are more frequent (34 specimens found) the juvenile ones.

Family Calyptraeidae Lamarck, 1809  
Genus *Crepidula* Lamarck, 1799  
*Crepidula moulinsii* Michaud, 1829  
(Fig. 1 V, W)

*Crepidula gibbosa* - Sacco, 1896a: p. 32, tav. IV, figg. 1-18.  
*Crepidula gibbosa* - Chirli, 1988: tav. II, figg. 1 a-c.  
*Crepidula gibbosa* - Cavallo & Repetto, 1992: p. 60, fig. 105.  
*Crepidula gibbosa* - Arduino et al., 1995: p. 51.  
*Crepidula gibbosa* - Giannuzzi-Savelli et al., 1997: figg. 615, 616.

## Remarks

The specific name *Crepidula moulinsii* Michaud, 1829 is actually used in place of *C. gibbosa* Defrance, 1818, but the latter has been widely used for this species. Sacco (1896a) states that *C. gibbosa* is a species “*immensamente variabile, tanto da assumere quelle diverse forme che vennero indicate come specie distinte, compresavi la vivente Moulinsii MICHX. del Mediterraneo; questa anzi sembrami più vicina alla C. gibbosa che non altre forme plioceniche e miocene* [extremely variable, to assume the various forms indicated as distinct species, including the *Moulinsii* MICHX., living in the Mediterranean; this seems to me more similar to *C. gibbosa* than to the other Pliocenic and Miocenic forms]”. This species lives on death shells and the adaptation to host shape and other unknown causes, determine the shell variability.

Family Naticidae Guilding, 1834  
Genus *Cochlis* Röding, 1798  
*Cochlis plicatula* (Bronn, 1831)  
(Fig. 1 X, Y)

*Cochlis plicatula* Bronn, 1831: p. 72.  
*Natica dillwini* var. *plicatula* - Sacco, 1891a: p. 62, tav. II, figg. 36 a-c.  
*Cochlis plicatula* - Pedriali & Robba, 2005: p. 146, pl. 2, figg. 6-11; pl. 7, fig. 3; pl. 9, fig. 8.  
*Cochlis plicatula* - Caprotti, 2011: p. 52, fig. 2 G-L.

## Remarks

The columellar callus is characteristic, matching the descriptions and illustrations in the above listed bibliographic references.

Genus *Tectonatica* Sacco, 1890  
*Tectonatica tectula* Sacco, 1891  
(Fig. 2 A, B)

*Natica (Tectonatica) tectula* - Sacco, 1891a: p. 81, tav. II, figg. 53 a, b.  
*Euspira catena* - Cavallo & Repetto, 1992: p. 68, fig. 126.  
*Tectonatica tectula* - Chirli, 2008: p. 70, tav. 27, figg. 1-6.  
*Tectonatica tectula* - Sosso & Dell’Angelo, 2010: pp. 26, 35.

## Remarks

Chirli (2008) correctly highlights that the specimen figured by Cavallo & Repetto (1992, fig. 126) is *T. tectula*, while the operculum belongs to *Euspira catena* (da Costa, 1778). This species, very frequent in most of sub-samples, even with juvenile specimens (in total number of 12 specimens), one of which is figured at Fig. 2 A, B. The juvenile specimens clearly belong to this species for the large semicircular aperture, the flat apex and, mainly, for parietal callus continuing in the umbilical callus and almost completely covering the umbilicus.

Naticidae juv.  
(Fig. 2 C, D)

## Remarks

The juvenile specimen of doubtful generic determination has been found in a sub-sample of group B; it is characterized by a wide semicircular aperture, depressed apex and thin parietal callus.

Family Ficidae Meek, 1864  
Genus *Ficus* Röding, 1798  
*Ficus subintermedia* (d’Orbigny, 1852)  
(Fig. 2 E-H)

*Ficula reticulata* var. *subintermedia* - Sacco 1891a: p. 33, tav. I, fig. 44.  
*Ficus conditus subintermedius* - Pavia, 1976: p. 140.  
*Ficus conditus subintermedius* - Cavallo & Repetto, 1992: p. 72, fig. 133.  
*Ficus subintermedia* - Negra & Lipparini, 2005: p. 103, fig. 3.  
*Ficus subintermedia* - Santucci, 2013: p. 133, fig. 5 M-O.

## Remarks

The nomenclatural history of the fossil species *Ficus subintermedia* (d’Orbigny, 1852) is reported by Sacco (1891a) and Pavia (1976). The above bibliographic references include Negra & Lipparini (2005) which figure with this name a recent specimen from South Africa. WoRMS uses *Ficus ficus* (Linnaeus, 1758) for the species presently living in the intertropical belt, not reaching the Mediterranean. Even Santucci (2013) uses the name *Ficus subintermedia* for the Pliocenic species and *Ficus ficus* for the living Indo-pacific species.

Family Aclididae Sars, 1878  
Genus *Aclis* Lovén, 1846  
*Aclis ascaris* (Turton, 1819)  
(Fig. 2 I, J)

*Turbo ascaris* Turton, 1819: p. 217.  
*Aclis ascaris* - Kobelt, 1905: p. 54, taf. LXV, figg. 6, 7.  
*Aclis ascaris* - Cossignani et al., 1992: fig. 114.  
*Aclis ascaris* - Arduino et al., 1995: p. 63.  
*Aclis ascaris* - Giannuzzi-Savelli et al., 1999: figg. 102-105.

## Remarks

Two specimens have been found. The shell is small,



elongate, subconical, the whorls are convex, suture oblique and deep, spiral sculpture consisting of three elevated cords, aperture ovoidal.

Family Epitoniidae Berry, 1910  
Genus *Epitonium* Röding, 1798  
***Epitonium algerianum* (Weinkauff, 1866)**  
**(Fig. 2 K, L)**

*Scalaria algeriana* Weinkauff, 1866: p. 247.  
*Scala (Parviscala) algeriana* - Kobelt, 1905: p. 12, taf. LX, fig. 1.  
*Epitonium algerianum* - Arduino et al., 1995: p. 64.  
*Epitonium algerianum* - Giannuzzi-Savelli et al., 1999: figg. 164, 165.

## Remarks

Two specimens have been found. The shell is turreted, the whorls are convex with an axial sculpture consisting of lamellae uncinata towards the adapical suture and very fine spiral striation in the interspaces, the aperture is subcircular.

***Epitonium mesogonium* (Brugnone, 1876)**  
**(Fig. 2 M, N)**

*Scalaria mesogonia* Brugnone, 1876: p. 16, tav. 1, fig. 22.  
*Fuscoscala mesogonia* - Sacco 1891b: p. 19.  
*Scala (Fuscoscala) mesogonia* - Pelosio, 1966: p. 121, tav. 36, figg. 4, 5.  
*Epitonium mesogonium* - Cavallo & Repetto, 1992: p. 78, fig. 155.  
*Epitonium mesogonium* - Chirli, 2009: p. 30, tav. 12, figg. 1-9.  
*Epitonium mesogonium* - Chirli & Linse, 2011: p. 102, pl. 30, figg. 2 a-d.

## Remarks

The species is characterized by the angulosity in the central portion the whorls, from which originate the specific name. The shell is turreted, with axial sculpture consisting of more or less thin lamellae, the aperture is subcircular and the lip is thickened.

Genus *Gyroscala* de Boury, 1887  
***Gyroscala pseudoscalare* (Brocchi, 1814)**  
**(Fig. 2 O, P)**

*Turbo pseudoscalaris* Brocchi, 1814: p. 379, tav. VII, fig. 1.  
*Scalaria (Opalia) pseudoscalaris* - Sacco 1891b: p. 31, tav. I, figg. 47, 48.  
*Epitonium pseudoscalare* - Cavallo & Repetto, 1992: p. 78, fig. 157.  
*Epitonium pseudoscalare* - Chirli, 2009: p. 32, tav. 13, figg. 1-6.  
*Epitonium pseudoscalare* - Chirli & Linse, 2011: p. 103, pl. 30, figg. 4 a-d.

## Remarks

The shell is characterized by a strongly turreted profile and very deep suture. The axial sculpture consists of lamellae, sometimes slightly uncinata, the aperture is subcircular, the external lip is thickened.

Family Nassariidae Iredale, 1916  
Genus *Nassarius* Duméril, 1805  
***Nassarius asperatus* (Cocconi, 1873)**  
**(Fig. 2 Q, R)**

*Nassa asperata* Cocconi, 1873: p. 489, tav. II, figg. 2-4.  
*Nassa asperata* - Bellardi, 1882: p. 116, tav. VII, figg. 19 a-c.  
*Nassa asperata* var. *miopliocenica* - Sacco, 1904: p. 68, tav. XVI, figg. 19, 20.  
*Nassarius (Hima) asperatus* - Cavallo & Repetto, 1992: p. 108, fig. 254.  
*Nassarius (Hima) asperatus* - Chirli, 2000: p. 71, tav. 28, figg. 9-12.  
*Nassarius asperatus* - Chirli & Linse, 2011: p. 154, pl. 52, figg. 1 a-c.

## Remarks

The three recorded specimens correspond to the *Nassa asperata* var. *miopliocenica* (Sacco, 1904) for the inflate profile (Fig. 2 Q, R), while the var. *plioturrita* shows a more slender profile. In general this species is quite variable.

***Nassarius cantrainei* (Bellardi, 1882)**  
**(Fig. 2 S, T)**

*Nassa Cantrainii* Bellardi, 1882: p. 78, tav. V, figg. 7 a, b.  
*Nassarius cantrainii* - Brunetti & Vecchi, 2005: p. 16, figg. 5c-e, 6i, 7i.

## Remarks

We deem useful to highlight the presence of this species scarcely reported by authors.

***Nassarius catulloi* (Bellardi, 1882)**  
**(Fig. 2 U, V)**

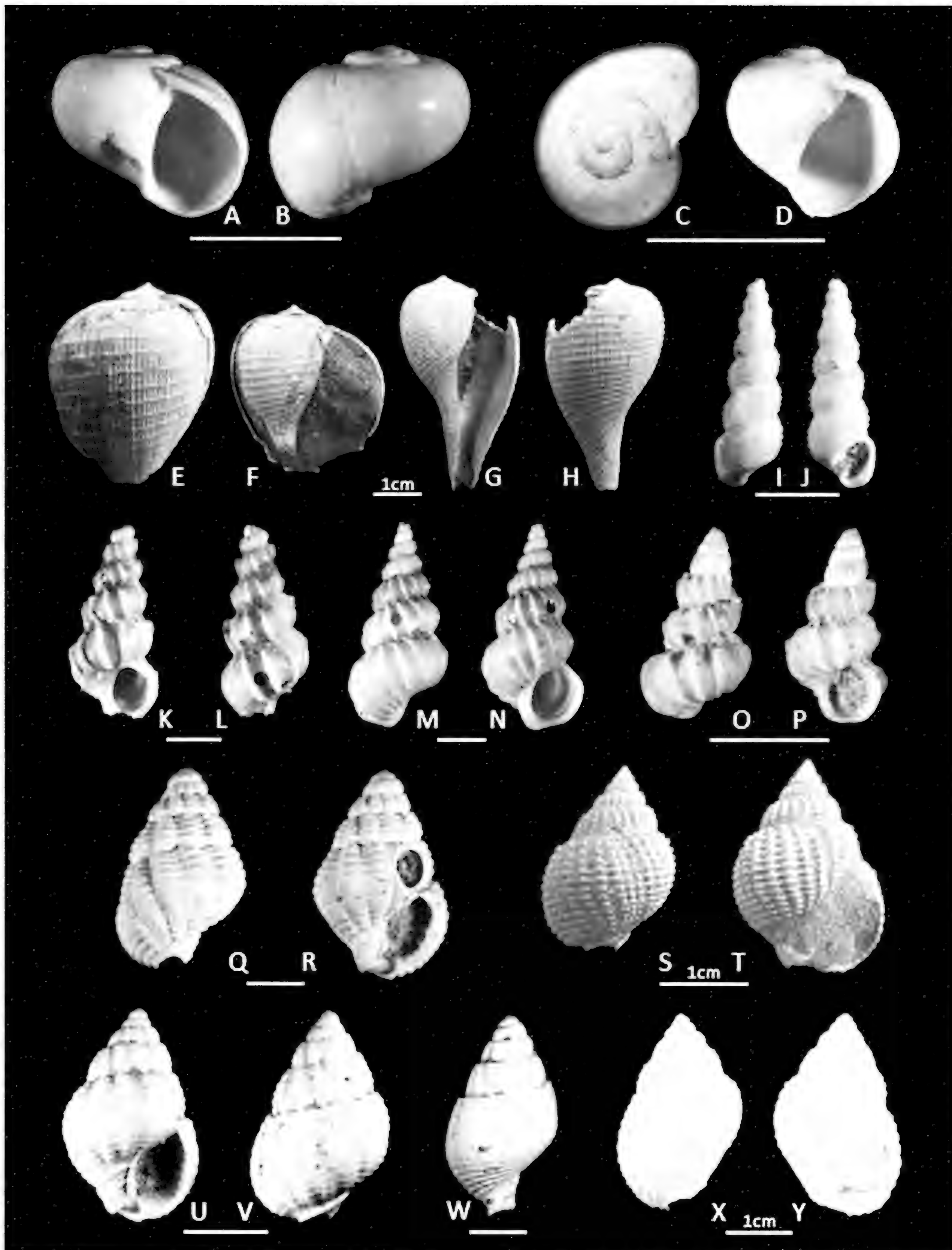
*Nassa Catulli* Bellardi, 1882: p. 109, tav. VII, figg. 5, 6.  
*Nassa sculptilis* - Bellardi, 1882: p. 110, tav. VII, figg. 9 a-c.  
*Nassa textilis* - Bellardi, 1882: p. 113, tav. VII, figg. 13 a-c.  
*Nassa textilis* var. *bivaricosa* - Sacco, 1904: p. 68, tav. XVI, fig. 16.  
*Nassa (Tritonella) catulloi* - Bernasconi, 1983: p. 106, tav. 1, figg. 1, 2.  
*Nassarius catulloi* - Gili & Martinell, 1990: p. 274, figg. 1-13.  
*Nassarius (Hima) catulloi* - Cavallo & Repetto, 1992: p. 108, fig. 255.  
*Nassarius (Hima) catulloi* - Chirli, 2000: p. 73, tav. 30, figg. 5-8.

## Remarks

We agree with Bernasconi (1983) in considering *Nassa sculptilis* and *N. textilis*, both described by Bellardi (1882), synonyms of *Nassa catulli* Bellardi, 1882. This species is rare in the studied locality (13 specimens found). It was first reported for the Tuscan Pliocene by Chirli (2000).

***Nassarius crebricostulatus* (Bellardi, 1882)**  
**(Fig. 2 W)**

*Nassa crebricostulata* Bellardi, 1882: p. 156, tav. X, figg. 2 a, b.



**Fig. 2.** A, B. *Tectonatica tectula* Sacco, 1891. C, D. Naticidae juv. E-H. *Ficus subintermedia* (d'Orbigny, 1852). I, J. *Aclis ascaris* (Turton, 1819). K, L. *Epitonium algerianum* (Weinkauff, 1866). M, N. *E. mesogonium* (Brugnone, 1876). O, P. *Gyroscala pseudoscalare* (Brocchi, 1814). Q, R. *Nassarius asperatus* (Cocconi, 1873). S, T. *N. cantrainei* (Bellardi, 1882). U, V. *N. catulloi* (Bellardi, 1882). W. *N. crebricostulatus* (Bellardi, 1882). X, Y. *N. emilianus* (Mayer, 1872). Scale bars = 1 mm (where not otherwise indicated).

**Fig. 2.** A, B. *Tectonatica tectula* Sacco, 1891. C, D. Naticidae juv. E-H. *Ficus subintermedia* (d'Orbigny, 1852). I, J. *Aclis ascaris* (Turton, 1819). K, L. *Epitonium algerianum* (Weinkauff, 1866). M, N. *E. mesogonium* (Brugnone, 1876). O, P. *Gyroscala pseudoscalare* (Brocchi, 1814). Q, R. *Nassarius asperatus* (Cocconi, 1873). S, T. *N. cantrainei* (Bellardi, 1882). U, V. *N. catulloi* (Bellardi, 1882). W. *N. crebricostulatus* (Bellardi, 1882). X, Y. *N. emilianus* (Mayer, 1872). Barre di scala = 1 mm (ove non diversamente indicato).



*Nassa crebricostulata* - Ferrero Mortara et al., 1981: tav. 31, figg. 1 a, b.  
*Nassarius crebricostulatus* - Cavallo & Repetto, 1992: p. 106, fig. 245.  
*Nassarius crebricostulatus* - Chirli, 2000: p. 65, tav. 27, figg. 1, 2.

Remarks

The shell is characterized by quite convex whorls and deep suture, the whorls are crenulate by the extremity of the axial ribs. The ribs tends to disappear on the last whorl. This species was first reported for the Tuscan Pliocene by Chirli (2000).

*Nassarius emilianus* (Mayer, 1872)  
 (Fig. 2 X, Y)

*Buccinum emilianus* Mayer, 1872: p. 236, pl. 14, fig. 9.  
*Nassa emiliana* - Bellardi, 1882: p. 77, tav. V, figg. 6 a, b.  
*Nassarius emilianus* - Brunetti & Vecchi, 2005: p. 9, figg. 3f-i, 6c, 7c.

Remarks

The found specimens are a little less slender with respect to specimens figured in referenced bibliography. This species differs from *N. clathratus* (Born, 1778) mainly for the smaller size, the less slender apex and spire, for one whorl less at similar height, and less canaliculate suture.

*Nassarius planicostatus* (Bellardi, 1882)  
 (Fig. 3 A, B)

*Nassa planicostata* Bellardi, 1882: p. 104, tav. VI, figg. 21 a-c.  
*Nassa (Hima) planicostata* var. *longastensis* - Sacco, 1904: p. 67, tav. XVI, figg. 11, 12.  
*Nassa planicostata* var. *subalpina* - Sacco, 1904: p. 67, tav. XVI, figg. 13, 14.  
*Nassarius (Uzita) planicostatus* - Cavallo & Repetto, 1992: p. 114, fig. 282.  
*Nassarius (Uzita) planicostatus* - Chirli, 2000: p. 102, tav. 39, figg. 9-12.

Remarks

A single specimen was found in a subsample of the group B. The specimen is similar to *Nassa planicostata* var. *subalpina* Sacco, 1904, to this variety seems to be referred the figures in Bellardi (1882), for the more globose outline. The fig. 21c in Bellardi (1882) it is clearly drawn the shell sculpture, characterized by axial ribs and flat spiral cords separate by narrow interspaces.

Genus *Tritia* Risso, 1826  
*Tritia pygmaea* (Lamarck, 1822)  
 (Fig. 3 C, D)

*Nassa pygmaea* Lamarck, 1822: p. 154.  
*Nassarius (Hima) cf. pygmaeus* - Cavallo & Repetto, 1992: p. 108, fig. 260.  
*Nassarius (Hima) pygmaeus* - Cossignani et al., 1992: fig. 146.

*Nassarius pygmaeus* - Arduino et al., 1995: p. 79.  
*Nassarius (Hima) pygmaeus* - Chirli, 2000: p. 78, tav. 29, figg. 9-12.

Remarks

The found specimen is more similar, among the illustrations in referenced bibliography, to that in Cavallo & Repetto (1992) and Arduino et al. (1995) mainly for the more globose outline.

Genus *Cyllene* Gray, 1834  
*Cyllene paulucciana* (D'Ancona, 1864)  
 (Fig. 3 E, F)

*Nassa paulucciana* D'Ancona in Foresti, 1864: p. 37.  
*Cyllenina paulucciana* - Bellardi, 1882: p. 164, tav. X, figg. 19 a, b.  
*Cyllenina paulucciana* - Sacco, 1904: p. 57, tav. XIV, figg. 53-55.  
*Dorsanum cf. pauluccianum* - Malatesta, 1974: p. 341, tav. XX-VII, fig. 5.  
*Dorsanum pauluccianum* - Pavia, 1976: tav. 6, figg. 21-27.  
*Cyllene paulucciana* - Cavallo & Repetto, 1992: p. 104, fig. 239.  
*Cyllene paulucciana* - Chirli, 2000: p. 110, tav. 41, figg. 3-8.

Remarks

A single specimen was found in a subsample of the group B. This species was described in detail by Malatesta (1974). It is characterized by the smooth protoconch, composed of two whorls, the presence of axial ribs and spiral grooves on the initial teleoconch whorls, the former tending to became weaker with the growth, while the spiral groove are not present on the following teleoconch whorls. Whorls convex, adapically depressed, aperture oval, base with spiral grooves.

Family Conidae Fleming, 1822  
 Genus *Conus* Linnaeus, 1758  
*Conus betulinoides* Lamarck, 1810  
 (Fig. 3 G)

*Conus betulinoides* Lamarck, 1810: p. 440.  
*Dendroconus betulinoides* - Sacco, 1893a: p. 4, tav. I, figg. 1-8.  
*Conus (Lithoconus) betulinoides* - Malatesta, 1974: p. 390, tav. XXX, fig. 6.  
*Conus betulinoides* - Pavia, 1976: tav. 9, figg. 1, 5.  
*Conus betulinoides* - Chirli, 1988: tav. X, fig. 1.  
*Conus betulinoides* - Spadini, 1990: p. 319, tav. 1, figg. 13, 14.  
*Conus betulinoides* - Cavallo & Repetto, 1992: p. 126, fig. 328.  
*Conus betulinoides* - Chirli, 1997: p. 16, tav. V, figg. 1-3.

Remarks

A single juvenile specimen was manually picked up. It is similar to the Sacco (1893a) varieties *exlineata* (Sacco, 1893a, tav. I, fig. 4) e *concavespirata* (Sacco, 1893a, tav. I, fig. 5), both characterised by a sub-concave spire. As stated by Sacco (1893a) "*esemplari giovani* (di *C. betulinoides*) *ricordano alquanto il C. pyrula* ed il *C. laeviponderosus* [juvenile specimens (of *C. betulinoides*) are similar to *C. pyrula* and *C. laeviponderosus*]" . The examined speci-

men is similar to the former, but markedly different from *Conus* (*Chelyconus*) *laeviponderosus* Sacco, 1893.

Family Mangeliidae P. Fischer, 1883  
Genus *Sorgenfreispira* Moroni, 1979  
***Sorgenfreispira brachystoma* (Philippi, 1844)**  
**(Fig. 3 H)**

*Pleurotoma brachystomum* Philippi, 1844: p. 169, tav. XXVI, fig. 10.  
*Raphitoma brachystoma* - Bellardi, 1877: p. 318, tav. IX, fig. 34.  
*Bela brachystoma* - Malatesta, 1974: p. 425, tav. XXXII, fig. 11.  
*Bela brachystoma* - Pavia, 1976: tav. 8, figg. 14, 15.  
*Bela brachystoma* - Terreni, 1981: p. 39, tav. VI, fig. 3.  
*Bela* (*Bela*) *brachystoma* - Cavallo & Repetto, 1992: p. 138, fig. 374.  
*Bela brachystoma* - Cossignani et al., 1992: fig. 163.  
*Bela brachystoma* - Arduino et al., 1995: p. 86.  
*Bela brachystoma* - Chirli, 1997: p. 50, tav. XIII, figg. 11, 12; tav. XIV, figg. 1, 2.  
*Bela brachystoma* - Chirli & Richard, 2008: p. 65, pl. 12, fig. 11.  
*Bela brachystoma* - Della Bella et. al., 2015: p. 18, figg. 37-44.

**Remarks**

This species is frequent in the studied material (23 specimens). It is variable and the studied specimens are similar to the photos in Malatesta (1974) and Pavia (1976, fig. 15). Mariottini et al. (2015) moved this species from genus *Bela* Gray, 1847 to genus *Sorgenfreispira* Moroni, 1979.

Genus *Bela* Gray, 1847  
***Bela hispidula* (Jan in Bellardi, 1847)**  
**(Fig. 3 I, J)**

*Raphitoma hispidula* Bellardi, 1847: p. 92, tav. IV, fig. 17.  
*Raphitoma hispidula* - Bellardi, 1877: p. 304, tav. IX, figg. 17, 18.  
*Raphitoma hispidula* var. *convexiuscula* - Sacco, 1904: p. 56, tav. XIV, fig. 38.  
*Raphitoma hispidula* var. *pliocostulatissima* - Sacco, 1904: p. 56, tav. XIV, fig. 39.  
*Neogurales hispidulus* - Cavallo & Repetto, 1992: p. 144, fig. 399.  
*Neogurales hispidulus* - Bogi & Cauli, 1997: p. 130, fig. 5.  
*Raphitoma hispidula* - Chirli, 1997: p. 80, tav. XXIII, figg. 1-4.  
*Bela hispidula* - Della Bella et al., 2015: p. 37, figg. 97-100.

**Remarks**

The four found specimens have been compared with recent specimens of the similar species *B. nuperrima* (Tiberi, 1855) from off Cefalù (south Tyrrhenian sea) and found different for the more numerous axial ribs, the more delicate sculpture and the last whorl more inflate. Therefore we consider that these two species are well separate.

***Bela zonata* (Locard, 1892)**  
**(Fig. 3 K, L)**

*Raphitoma zonatum* Locard, 1892: p. 58.  
*Bela laevigata* - Nordsieck, 1968: p. 171.

*Bela laevigata* var. *zonata* - Nordsieck, 1968: p. 171.  
*Bela laevigata* - Arduino et al., 1995: p. 86.

**Remarks**

Only two incomplete specimens were found. This name replaces the well known *Bela laevigata* (Philippi, 1836).

Genus *Mangelia* Risso, 1826  
***Mangelia attenuata* (Montagu, 1803)**  
**(Fig. 3 M, N)**

*Murex attenuatus* Montagu, 1803: p. 266, tav. IX, fig. 6.  
*Raphitoma* (*Villiersiella*) *attenuata* - Sacco, 1904: p. 56, tav. XIV, figg. 43, 44.  
*Cythara* (*Mangelia*) *attenuata* - Nordsieck, 1968: p. 168, taf. XXVIII, fig. 92.90.  
*Mangelia attenuata* - Malatesta, 1974: p. 423, tav. XXXII, fig. 7.  
*Cythara* (*Mangelia*) *attenuata* - Pavia, 1976: tav. 8, figg. 13 a, b.  
*Mangelia attenuata* - Rosso, 1979: tav. 16, fig. 15.  
*Mangelia attenuata* - Cavallo & Repetto, 1992: p. 142, fig. 387.  
*Mangelia attenuata* - Arduino et al., 1995: p. 88.  
*Mangelia attenuata* - Chirli & Richard, 2008: p. 66, pl. 13, fig. 5.  
*Mangelia attenuata* - Chirli & Linse, 2011: p. 179, pl. 64, figg. 1 a-e.

**Remarks**

A single specimen has been found in a sub-sample of the group B. This species is characterized by the elongate profile, the multispiral protoconch, the smooth surface and the axial ribs separate by wide interspaces.

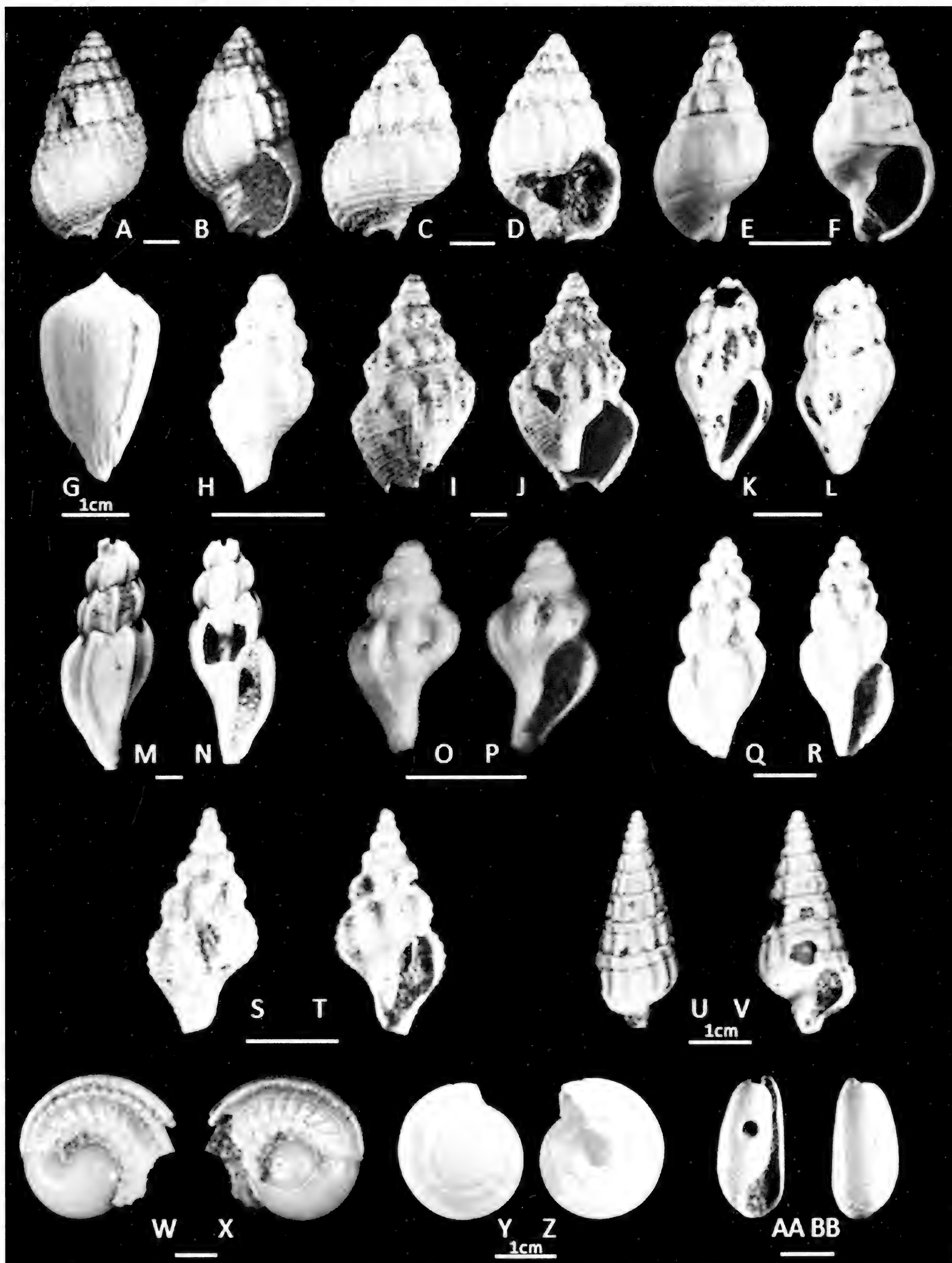
***Mangelia* cf. *costata* (Pennant, 1777)**  
**(Fig. 3 O, P)**

*Mangilia costata* - Sacco, 1904: p. 55, tav. XIV, fig. 20.  
*Cythara* (*Cytharella*) *costata* - Nordsieck, 1968: p. 165, taf. XXVI-II, fig. 92.40.  
*Cythara* (*Cytharella*) *costata coarctata* - Nordsieck, 1968: p. 165, taf. XXVIII, fig. 92.41.  
*Cytharella costata* - Malatesta, 1974: p. 432, tav. XXXII, fig. 9.  
*Mangelia costata* - Cavallo & Repetto, 1992: p. 142, fig. 388.  
*Mangelia coarctata* - Cossignani et al., 1992: fig. 166.  
*Mangelia costata* - Cossignani et al., 1992: fig. 167.  
*Mangelia coarctata* - Arduino et al., 1995: p. 88.  
*Mangelia costata* - Arduino et al., 1995: p. 88.  
*Mangelia costata* - Chirli, 1997: p. 67, tav. XIX, figg. 8-10.  
*Mangelia coarctata* - Chirli & Richard, 2008: p. 67, pl. 13, fig. 6.  
*Mangelia coarctata* - Scarponi & Della Bella, 2010: p. 20, figg. 25-32.  
*Mangelia costata* - Scarponi & Della Bella, 2010: p. 21, figg. 33-36.

**Remarks**

Two juvenile specimens have been found. This species is characterized by the elongate profile, the multispiral protoconch, the smooth surface and the axial ribs separate by wide interspaces. With respect to *M. attenuata*, it is stouter, has a more regularly convex whorl profile and thickened external lip. As *Mangelia coarctata* (Forbes,





**Fig. 3.** A, B. *Nassarius planicostatus* (Bellardi, 1882). C, D. *Tritia pygmaea* (Lamarck, 1822). E, F. *Cyllene paulucciana* (D'Ancona, 1864). G. *Conus betuloides* Lamarck, 1810. H. *Sorgenfreispira brachystoma* (Philippi, 1844). I, J. *Bela hispidula* (Jan in Bellardi, 1847). K, L. *B. zonata* (Locard, 1892). M, N. *Mangelia attenuata* (Montagu, 1803). O, P. *M. cf. costata* (Pennant, 1777). Q, R. *M. unifasciata* (Deshayes, 1835). S, T. *Leufroyia raynevali* (Bellardi, 1877). U, V. *Terebra reticularis* (Pecchioli in Sacco, 1891). W, X. *Basisulcata simplex* juv. (Bronn, 1831). Y, Z. *B. simplex* (Bronn, 1831). AA, BB. *Retusa nitidula* (Lovén, 1846). Scale bars = 1 mm (where not otherwise indicated).

**Fig. 3.** A, B. *Nassarius planicostatus* (Bellardi, 1882). C, D. *Tritia pygmaea* (Lamarck, 1822). E, F. *Cyllene paulucciana* (D'Ancona, 1864). G. *Conus betuloides* Lamarck, 1810. H. *Sorgenfreispira brachystoma* (Philippi, 1844). I, J. *Bela hispidula* (Jan in Bellardi, 1847). K, L. *B. zonata* (Locard, 1892). M, N. *Mangelia attenuata* (Montagu, 1803). O, P. *M. cf. costata* (Pennant, 1777). Q, R. *M. unifasciata* (Deshayes, 1835). S, T. *Leufroyia raynevali* (Bellardi, 1877). U, V. *Terebra reticularis* (Pecchioli in Sacco, 1891). W, X. *Basisulcata simplex* juv. (Bronn, 1831). Y, Z. *B. simplex* (Bronn, 1831). AA, BB. *Retusa nitidula* (Lovén, 1846). Barre di scala = 1 mm (ove non diversamente indicato).

1840) is actually considered synonym of *M. costata*, the records under this name are above listed. The found specimens are similar to that figured by Cossignani et al. (1992, fig. 167).

***Mangelia unifasciata* (Deshayes, 1835)  
(Fig. 3 Q, R)**

- Pleurotoma unifasciata* Deshayes, in Bory de Saint-Vincent, 1835: p. 177, tav. 19, figg. 34-36.  
*Mangilia rugulosa* - Sacco, 1904: p. 55, tav. XIV, figg. 23, 24.  
*Mangelia galli* - Kobelt, 1905: p. 340, taf. XCIV, figg. 8, 9.  
*Cythara (Cytharella) rugulosa* - Nordsieck, 1968: p. 165, taf. XX-VIII, fig. 92.42.  
*Cytharella rugulosa* - Malatesta, 1974: p. 433, tav. XXXII, fig. 8.  
*Cythara rugulosa* - Pavia, 1976: tav. 8, figg. 8 a, b.  
*Mangelia unifasciata* - Cavallo & Repetto, 1992: p. 142, fig. 391.  
*Mangelia unifasciata* - Cossignani et al., 1992: fig. 170.  
*Mangelia unifasciata* - Arduino et al., 1995: p. 90.  
*Mangelia unifasciata* - Chirli, 1997: p. 71, tav. XXI, figg. 1, 2.  
*Mangelia unifasciata* - Scarponi & Della Bella, 2010: p. 53, figg. 141-156.

**Remarks**

Five well preserved specimens (2 in sub-samples of the group A and 3 by picking) specimens have been found. This species is highly variable, with several synonyms still under discussion (see Scarponi & Della Bella, 2010). It is characterized by the elongate profile, the multispiral protoconch, the spiral sculpture consisting of fine spiral cords, few stronger than the others, and the thickened external lip.

**Family Raphitomidae Bellardi, 1875  
Genus *Leufroyia* Monterosato, 1884  
*Leufroyia raynevali* (Bellardi, 1877)  
(Fig. 3 S, T)**

- Homotoma Raynevali* Bellardi, 1877: p. 274, tav. VIII, fig. 24.  
*Comarmondia raynevali* - Cavallo & Repetto, 1992: p. 146, fig. 405.  
*Raphitoma raynevali* - Chirli, 1997: p. 87, tav. XXV, figg. 1-4.  
*Raphitoma raynevali* - Chirli & Richard, 2008: p. 69, pl. 14, fig. 1.  
*Raphitoma raynevali* - Chirli & Linse, 2011: p. 175, pl. 62, figg. 1 a-e.

**Remarks**

This species, very rare in the studied material (6 specimens), is characterized by turreted outline, protoconch consisting of four whorls, the last with a spiral carina. The teleoconch whorls are convex, with strong axial ribs separate by wide interval, and elevated spiral cords. The aperture is oval, with arched columella.

**Family Terebridae Adams H. & Adams A., 1853  
Genus *Terebra* Bruguière, 1789  
*Terebra reticularis* (Pecchioli in Sacco, 1891)  
(Fig. 3 U, V)**

- Strioterebrum reticulare* Pecchioli in Sacco, 1891c: p. 40, tav. II, figg. 20-34.

*Strioterebrum (Strioterebrum) cf. reticulare* - Malatesta, 1974: tav. XXXII, fig. 3.

- Strioterebrum reticulare* - Pavia, 1976: tav. 9, figg. 15, 16.  
*Terebra reticulare* - Bouchet, 1982: p. 195, figg. 6, 30-33.  
*Strioterebrum reticulare* - Chirli, 1988: tav. XI, fig. 3.  
*Strioterebrum reticulare* - Cavallo & Repetto, 1992: p. 148, fig. 412 a.  
*Strioterebrum reticulare* - Chirli, 1997: p. 22, tav. VI, figg. 11-14.  
*Terebra reticulare* - Sosso & Dell'Angelo, 2010: pp. 50, 65.

**Remarks**

Several specimens have been manually picked up, but it is rare in the examined sub-samples. It is considered by some Authors synonym of *Strioterebrum pliogenicum* (Fontannes, 1881). Based on the weak sculpture and the large shell size, the found specimens have been referred to *T. reticularis*.

**Family Architectonicidae Gray J.E., 1850  
Genus *Basisulcata* Melone & Taviani, 1984  
*Basisulcata simplex* (Bronn, 1831)  
(Fig. 3 W-Z)**

- Solarium simplex* Bronn, 1831: p. 63.  
*Solarium simplex* - Sacco, 1892: p. 45, tav. I, figg. 49-59.  
*Solarium simplex* - Sacco, 1904: p. 111, tav. XXIV, fig. 37.  
*Architectonica (Architectonica) simplex* - Malatesta, 1974: p. 182, tav. XIII, figg. 3 a, b.  
*Architectonica simplex* - Chirli, 1988: tav. I, figg. 7 a-c.  
*Basisulcata simplex* - Cavallo & Repetto, 1992: p. 150, fig. 415.  
*Basisulcata simplex* - Bogi et al., 2002: p. 32, figg. 1, 2.  
*Basisulcata simplex* - Chirli & Richard, 2008: p. 73, pl. 14, fig. 10.  
*Basisulcata simplex* - Sosso & Dell'Angelo, 2010: pp. 50, 66.  
*Basisulcata simplex* - Chirli & Linse, 2011: p. 211, pl. 84, figg. 1 a-f.  
*Basisulcata simplex* - Chirli, 2013: p. 7, tav. 2, figg. 7-15.

**Remarks**

Two fully grown (Fig. 3 Y, Z) and one juvenile (Fig. 3 W, X) specimen have been manually picked up, missing in the examined sub-samples. Some Authors discussed the relation of this species with the living *B. lepida* (Bayer, 1942).

**Family Retusidae Thiele, 1925  
Genus *Retusa* Brown, 1827  
*Retusa nitidula* (Lovén, 1846)  
(Fig. 3 AA, BB)**

- Cylichna nitidula* - Seguenza, 1873: pp. 294, 295.  
*Cylichna nitidula* - Seguenza, 1875: pp. 150, 151.  
*Cylichna nitidula* - Seguenza, 1880: pp. 252, 318, 351.  
*Cylichnina nitidula* - Gaglini, 1991: pp. 10, 19.  
*Cylichnina nitidula* - Gruppo malacologico livornese, 2004: pp. 63, 72.

**Remarks**

There are very few records as fossil of this species. The shell is characterized by the ovoidal outline, remark-



ably enlarging towards the anterior side, the surface smooth or with extremely fine growth lines.

Classe Bivalvia Linnaeus, 1758  
Family Nuculidae Gray, 1824  
Genus *Nucula* Lamarck, 1799  
*Nucula jeffreysi* Bellardi, 1875  
(Fig. 4 A, B)

*Nucula jeffreysi* Bellardi, 1875: p. 12, fig. 6.  
*Nucula jeffreysi* - Sacco, 1898: p. 49, tav. XI, figg. 20-23.  
*Nucula jeffreysi* - Cavallo & Repetto, 1992: p. 176, fig. 515.  
*Nucula jeffreysi* - Ferrero et al., 2005: tav. 1, fig. 5.

## Remarks

This species is common in the studied material (233 specimens). The shell is characterized by convex, sub-triangular valves, sculptures by concentric ribs separate by narrow interspaces, the internal ventral margin is finely crenulated.

*Nucula nitidosa* Winckworth, 1930  
(Fig. 4 C, D)

*Nucula nitida* - Sacco, 1898: p. 47, tav. XI, figg. 5, 6.  
*Nucula turgida nitidosa* - Nordsieck, 1969: p. 5, taf. I, fig. 00.14.  
*Nucula nitida* - Pavia, 1976: tav. 12, figg. 12, 13.  
*Nucula nitidosa* - Cavallo & Repetto, 1992: p. 176, fig. 516.  
*Nucula nitidosa* - Cossignani et al., 1992: fig. 253.

## Remarks

Also this species is common in the studied material (144 specimens). Its outline is similar to *Nucula jeffreysi*, but the surface is sculptured by very weak radiating lines and growth lines.

Family Malletidae Adams H. & Adams A., 1858  
Genus *Malletia* Des Moulins, 1832  
*Malletia* sp.  
(Fig. 4 E, F)

## Remarks

The four juvenile specimens cannot be determined at specific level, but show some resemblance with the figures of *Pseudomalletia obtusa* (Sars, 1872) and *P. caterinii* (Appelius, 1871) in La Perna (2003, fig. 3-4). Genus *Pseudomalletia* Fischer, 1886 has been synonymised with *Malletia* (fide Huber, 2010).

Family Pectinidae Rafinesque, 1815  
Genus *Pecten* Müller, 1776  
*Pecten bosniasckii* De Stefani & Pantanelli, 1878  
(Fig. 4 G)

*Pecten flabelliformis* var. *Bosniasckii*, De Stefani & Pantanelli, 1878: p. 29.  
*Flabellipecten Bosniasckii* - Sacco, 1897b: p. 56, tav. XVII, figg. 1-8.

*Pecten (Flabellipecten) bosniasckii* - Cavallo & Repetto, 1992: p. 186, fig. 548.

## Remarks

We agree with Sacco (1897b) in that this species differs from *Pecten flabelliformis* (Brocchi, 1814) because it is "più piccola e relativamente un po' più gibbosa nella valva destra, per aver le coste principali in minor numero, più rilevate e quindi separate da solchi più profondi [smaller and with the right valve more gibbose, main ribs in lower number, more elevate and then separate by deeper interspaces]".

*Pecten flabelliformis persulculata* (Sacco, 1897)  
(Fig. 4 H, I)

*Flabellipecten flabelliformis* var. *persulculata* Sacco, 1897b: p. 56, tav. XVI, fig. 5.

## Remarks

The found fragments well correspond to the original description (*Valvae sinistrae costae radiales longitudinaliter uno vel bisulcatae* [left valve with bisulcate radial ribs]) and drawing of this subspecies.

Family Cardiidae Lamarck, 1809  
Genus *Acanthocardia* Gray, 1851  
*Acanthocardia* sp.  
(Fig. 4 J, K)

## Remarks

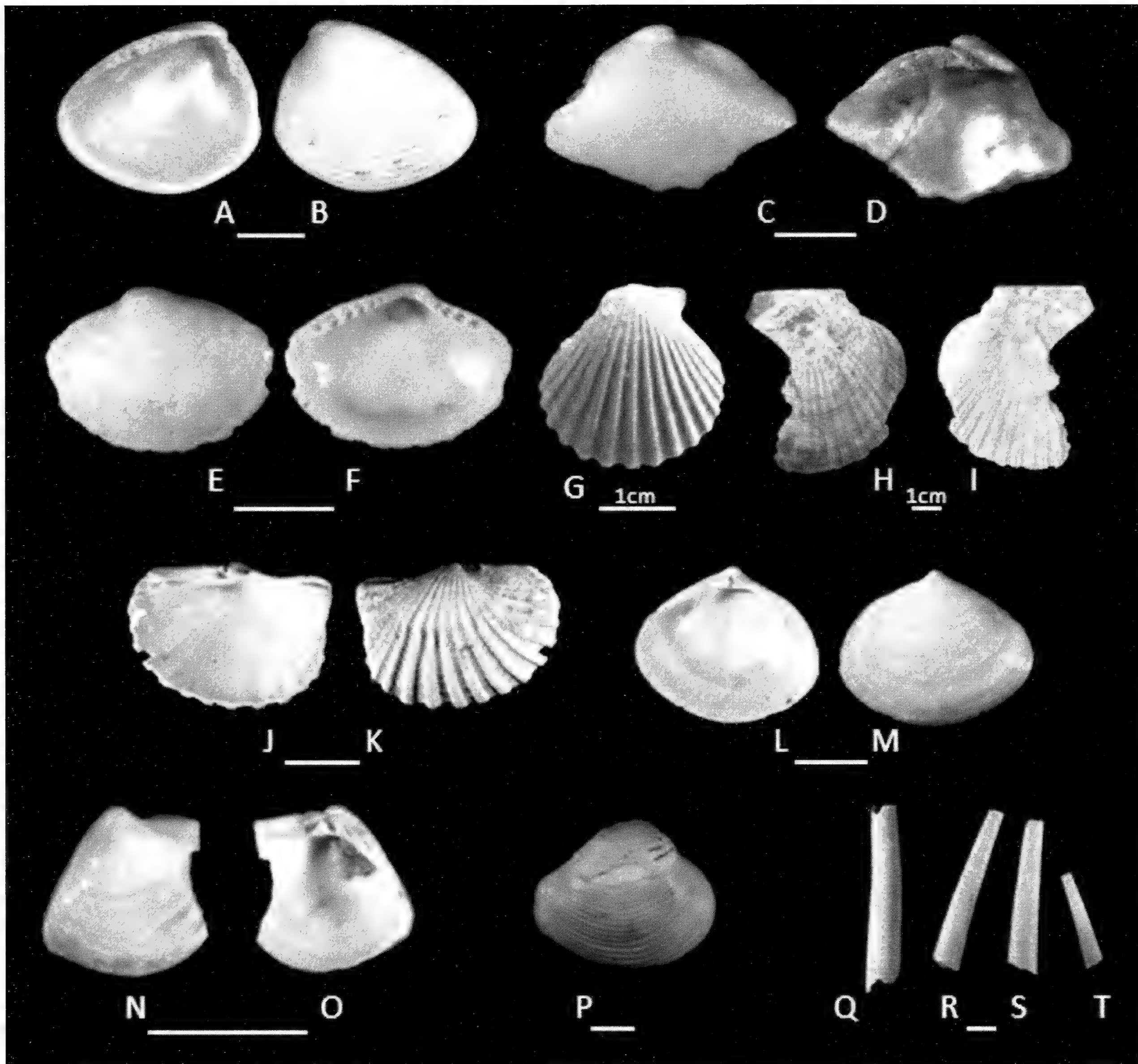
The six juvenile specimens, all found in the sub-sample A3, are also damaged and have not permitted a determination at specific level. They are characterized by a straight dorsal margin, quite pointed beaks, radial ribs quite convex, roughly large as the interspaces. Well developed concentric cordes are present in the interspaces and above the ribs. The radial sculpture is shaping also the internal side of the valve.

Family Mesodesmatidae Gray J.E., 1840  
Genus *Ervilia* Turton, 1822  
*Ervilia castanea* (Montagu, 1803)  
(Fig. 4 L, M)

*Donax castaneus* Montagu, 1803: p. 573, tav. 17, fig. 2.  
*Ervilia castanea* - Sacco, 1901: p. 21.  
*Ervilia castanea* - Tebble, 1966: p. 136, fig. 73 n.t.  
*Ervilia castanea* - Nordsieck, 1969: p. 139, taf. XX, fig. 80.11.  
*Ervilia castanea* - Arduino et al., 1995: p. 154.

## Remarks

This species is quite frequent in the studied material (30 specimens). Normally the iconography shows large specimens, while the small ones (as those studied for the present work) have a quite equilateral outline, with



**Fig. 4.** A, B. *Nucula jeffreysi* Bellardi, 1875. C, D. *N. nitidosa* Winckworth, 1930. E, F. *Malletia* sp. G. *Pecten bosniasckii* De Stefani & Pantanelli, 1878. H, I. *P. flabelliformis persulculata* (Sacco, 1897). J, K. *Acanthocardia* sp. L, M. *Ervilia castanea* (Montagu, 1803). N, O. *Dosinia* sp. P. *Corbula gibba* (Olivi, 1792). Q-T. *Omniglypta jani* (Hörnes, 1856). Scale bars = 1 mm (where not otherwise indicated).

**Fig. 4.** A, B. *Nucula jeffreysi* Bellardi, 1875. C, D. *N. nitidosa* Winckworth, 1930. E, F. *Malletia* sp. G. *Pecten bosniasckii* De Stefani & Pantanelli, 1878. H, I. *P. flabelliformis persulculata* (Sacco, 1897). J, K. *Acanthocardia* sp. L, M. *Ervilia castanea* (Montagu, 1803). N, O. *Dosinia* sp. P. *Corbula gibba* (Olivi, 1792). Q-T. *Omniglypta jani* (Hörnes, 1856). Barre di scala = 1 mm (ove non diversamente indicato).

the characteristic prominent umbo roughly placed in central position.

Family Veneridae Rafinesque, 1815  
Genus *Dosinia* Scopoli, 1777  
*Dosinia* sp.  
(Fig. 4 N, O)

#### Remarks

The eleven juvenile specimens are damaged and not determinable at specific level. They appear quite similar to the specimens of *Dosinia lupinus*, very frequent (88 specimens found) in the studied material, but they differ for the less convex profile and the lunule less arcuate and less marked.

Family Corbulidae Lamarck, 1818  
Genus *Corbula* Bruguière, 1797  
*Corbula gibba* (Olivi, 1792)  
(Fig. 4 P)

*Tellina gibba* Olivi, 1792: p. 101.  
*Corbula gibba* - Hoernes, 1870: p. 34, taf. 3, fig. 7.  
*Corbula gibba* - Sacco, 1901: p. 34, tav. IX, figg. 1-11.  
*Corbula gibba* - Nordsieck, 1969: p. 149, taf. XXI, fig. 84.00.  
*Corbula gibba* - Malatesta, 1974: p. 153.  
*Corbula gibba* - Cavallo & Repetto, 1992: p. 224, fig. 675.  
*Corbula (Varicorbula) gibba* - Cossignani et al., 1992: fig. 386.  
*Corbula gibba* - Piccardi, 1994: pl. 1, fig. 4.  
*Corbula gibba* - Arduino et al., 1995: p. 163.  
*Corbula gibba* - Chirli & Richard, 2008: p. 103, pl. 23, f. fig. 6.  
*Corbula gibba* - Sosso & Dell'Angelo, 2010: pp. 77, 83.



## Remarks

This species is very common in the studied material (451 specimens found). The found valves show concentric ridges only present near the ventral margin, while the figured right valve shows the sculpture on all the valve.

Classe Scaphopoda Bronn, 1862  
Family Omniglyptidae Chistikov, 1975  
Genus *Omniglypta* Kuroda & Habe in Habe, 1953  
*Omniglypta jani* (Hörnes, 1856)  
(Fig. 4 Q-T)

*Dentalium Jani* Hörnes, 1856: p. 657, taf. 50, fig. 37.

*Dentalium (Fustiaria) Jani* - Sacco, 1897a: p. 112, tav. X, figg. 25-33.

*Fustiaria (Fustiaria) jani* - Caprotti, 1979: p. 240, tav. XI, figg. 1, 6-8.

*Gadilina jani* - Pavia, 1991: p. 128, tav. 6, figg. 7-10; tav. 7, figg. 1, 2.

*Gadilina jani* - Cavallo & Repetto, 1992: p. 230, fig. 699.

*Gadilina jani* - Bogi & Cauli, 1997: p. 133.

*Omniglypta jani* - Sosso & Dell'Angelo, 2010: pp. 70, 72.

*Omniglypta jani* - Chirli, 2013: p. 91, tav. 23, figg. 1-7.

## Remarks

This species is characterized by the subcircular section and the rounded ribs on the whole length. Reported for the first time in the Pliocene of Tuscany by Bogi & Cauli (1997) as *Gadilina jani*.

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# Description of *Alvania annetteae* spec. nov. from the Mediterranean Sea (Mollusca, Gastropoda, Rissoidae)

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## Abstract

A new Mediterranean species of the genus *Alvania* (Rissooidea, Rissoidae) is described: *Alvania annetteae* spec. nov. All known specimens come from the type locality: Saint-Raphaël, Côte d'Azur, Southern France. It is compared with the most similar congeners from Mediterranean Sea: *Alvania hallgassi* Amati & Oliverio, 1985, *Alvania daniensis* Oliverio, 1988, *Alvania dalmatica* Buzzurro & Prkić, 2007, *Alvania testae* (Aradas & Maggiore, 1844), *Alvania subsoluta* (Aradas, 1847), *Alvania desabatae* Amati & Smriglio, 2016 and *Alvania marmarisensis* Bitlis Bakir & Öztürk, 2017.

## Key words

Gastropoda, Rissoidae, *Alvania* spec. nov., Mediterranean Sea, taxonomy

## Riassunto

Viene descritta una nuova specie del genere *Alvania* (Rissooidea, Rissoidae) dal Mar Mediterraneo: *Alvania annetteae* spec. nov. Tutti gli esemplari conosciuti provengono dalla località tipo: Saint-Raphaël, Costa Azzurra, Francia meridionale. Viene confrontata con le congeneri più simili del Mar Mediterraneo: *Alvania hallgassi* Amati & Oliverio, 1985, *Alvania daniensis* Oliverio, 1988, *Alvania dalmatica* Buzzurro & Prkić, 2007, *Alvania testae* (Aradas & Maggiore, 1844), *Alvania subsoluta* (Aradas, 1847), *Alvania desabatae* Amati & Smriglio, 2016 e *Alvania marmarisensis* Bitlis Bakir & Öztürk, 2017.

## Parole chiave

Gastropoda, Rissoidae, *Alvania* spec. nov., Mar Mediterraneo, tassonomia

## Introduction

The genus *Alvania* Risso, 1826 as currently conceived, comprises 360 species of which 255 Recent (GOFAS, 2014). In the Mediterranean Sea the genus *Alvania* s.s. is well represented by 74 accepted Recent species (Gofas & Le Renard, 2015) and includes several species-complex (e. g. *Alvania lineata* Risso, 1826, *Alvania dictyophora* (Philippi, 1844), *Alvania scabra* (Philippi, 1844), *Alvania subcrenulata* (Bucquoy, Dautzenberg & Dollfus, 1884), *Alvania testae* (Aradas & Maggiore, 1844) and *Alvania hallgassi* Amati & Oliverio, 1985), each with wide ranges and a non-planktotrophic development in most species. This genus includes a group of small marine rissoids (Gastropoda, Rissoidae) living mostly from the lower intertidal zone down to 4700 m depth (Bouchet & Warén, 1993: 637), prevalently constantly associated with algal facies (e.g. Tringali, 2001: 208; Amati, 2012: 117), and feeding on diatoms, dino-flagellates, and detritus, or, presumably, some deep-sea species may be selective deposit feeders (Ponder, 1985: 2).

In the Mediterranean Sea, from the deeper continental shelf to the bathyal depths, live 8 species of *Alvania*, all on detritic-muddy bottoms, in 100-2000 m depth, occasionally down to 2800 m depth (Bouchet & Warén, 1993: 636): *Alvania cimicoides* (Forbes, 1844), *Alvania testae* (Aradas & Maggiore, 1844), *Alvania tomentosa* (Pallary, 1920), *Alvania dipacoi* Giusti & Nofroni, 1989, *Alvania*

*subsoluta* (Aradas, 1847), *Alvania zylensis* Gofas & Warén, 1982, *Alvania elegantissima* (Monterosato, 1875) and *Alvania zetlandica* (Montagu, 1815). Specimens from a population of the *Alvania hallgassi*-complex sampled at 300-500 m depth, off Côte d'Azur (Southern France), proved morphologically distinct from all other known species. It is here described as new, and compared with the species in the *A. hallgassi*-complex and other similar species from the Mediterranean Sea.

## Material and methods

### Abbreviations and acronyms

AH: Alessandro Hallgass collection (Rome, Italy); BA: Bruno Amati collection (Rome, Italy); CD: Claude Danzelle collection (Saint-Raphaël, France); CS-PM: Carlo Smriglio-Paolo Mariottini collection (Rome, Italy); EDS: Eleonora De Sabata collection (Rome, Italy); GD: Gilles Devauchelle collection (Fréjus, France); IN: Italo Nofroni collection (Rome, Italy); MCZR: Museo Civico di Zoologia (Rome, Italy); MGU: Museo Geologico dell'Università (Florence, Italy); MNHN: Museum Nationale d'Histoire Naturelle (Paris, France); MZB: Laboratorio e Museo di Malacologia Università (Bologna, Italy); MO: Marco Oliverio collection (Rome, Italy); PT: Piergiorgio Trillò collection (Rome, Italy); sh: empty shell(s); v: varix; v.: versus.



Material examined

The samples studied herein are stored in public and private collections, as detailed below, and all shells have been sorted out of bioclastic sediment samples. Current systematics is based on the World Register of Marine Species. Measurements were taken on a random sample of 4 specimens and are reported in **Tab. 1**.

*Alvania annetteae* spec. nov. (see below for details of types and other material examined).

*Alvania hallgassi* Amati & Oliverio, 1985. Type material: (MCZR, AH, BA, MO); Lastovo Is. (Croatia) 38-50 m depth, 62 sh (BA); Maratea, Sant’Janni Is. (Italy) 24 m depth, 11 sh (BA); Capri Is., “Grotta azzurra” (Italy) 14 m depth, 26 sh (CS-PM); Marina di Camerota (Italy) 30 m depth, 8 sh (CS-PM); Capo Palinuro, Grotta “Cock-Pit” (Italy), 12 m depth, 26 sh (CS-PM); Capo Asparano (Italy) 1 sh (BA).

*Alvania dianiensis* Oliverio, 1988. Type material: Giannutri Is., Cala dei Grottoni (Italy) 48 m depth (GG48) 3 paratypes (BA); Giglio Is., Secca Subbielli (Italy) 38 m depth, 8 sh (BA); Giannutri Is. (Italy) 40 m depth, 19 sh (CS-PM); Marina di Camerota (Italy) 30 m depth, 3 sh (CS-PM); Capo Palinuro, cave (Italy) 20 m depth, 5 sh (CS-PM).

*Alvania dalmatica* Buzzurro & Prkić, 2007. Lastovo Is. (Croatia) 60-90 m depth, 1 sh (CS-PM).

*Alvania testae* (Aradas & Maggiore, 1844). Santa Teresa di Gallura (Italy), muddy bottom vii.1991, 3 sh (BA), Gulf of Alghero (Italy) 150 m depth 1978, 14 sh (BA), Capraia Is. (Italy) 440 m depth viii.1990, 42 sh (BA), Tuscan Archipelago (Italy) 270 m depth 1987, 15 sh

(BA), Fiumicino (Italy) ex *Astropecten* sp. 1990-1992, 56 sh (BA), Fiumicino (Italy) 1978, 7 sh (BA), Gorgona Is. (Italy) 3 sh (BA), Anzio (Italy) muddy bottom 120 m depth vi.1989, 5 sh (BA), Fossa Roseto degli Abruzzi (Italy) 150 m depth 1991, 80 sh (BA).

*Alvania subsoluta* (Aradas, 1847). Type material (MGU); Civitavecchia (Italy) 550 m depth, muddy debris in old Roman amphora, 1500 sh (BA), Fiumicino (Italy) muddy bottom iv.1982, 1 sh (BA); Central Tyrrhenian Sea (Italy) 250 m depth, muddy bottom, 540 m depth, 2000 sh and specimens (CS-PM).

*Alvania desabatae* Amati & Smriglio, 2016. Type material (MNHN IM-2000-31759-60; MZB 60204-5; MCZR 00229A-B; BA; CS-PM; EDS; IN; MO; PT); Ponza Is. (Italy) 60 m depth, Central Tyrrhenian Sea, 2011, 136 sh (including 57 sh juveniles and 14 sh broken) (CS-PM); Ponza Is., P.ta La Guardia (Italy) 50 m depth, Central Tyrrhenian Sea, 2 sh (MO); Ventotene Is., ‘Sconcioglie’ (Italy) shoal 33 m depth, Central Tyrrhenian Sea, 1984, 19 sh (MO); Zannone Is. (Italy) 36.5 m depth, Central Tyrrhenian Sea, viii.2013, 3 sh (IN).

Photographic methods

Photographs have been taken with a Sony Cyber-Shot digital camera mounted on a Kyowa KBS stereomicroscope, stack-edited with the Combine-Z software (HADLEY, 2006). Scanning Electron Microscope (SEM) photographs were taken at the Interdepartmental Laboratory of Electron Microscopy (LIME: University “Roma Tre”, Rome) by using a Philips XL30.

Teleoconch	1	2	3	4	Min/max	Mean
Height	3.05	3.05	3.2	3	3-3.2	3.075
Width	1.75	1.9	1.9	1.75	1.75-1.9	1.825
Aperture height	1.3	1.35	1.4	1.25	1.25-1.4	1.325
Height/Width ratio	1.743	1.605	1.684	1.714	1.605-1.743	1.686
Height/aperture height	2.346	2.259	2.286	2.400	2.259-2.400	2.322
Number of whorls	3.9	4	4	4	3.9-4	3.975
Number of denticles	9	no	10	11	no/9-11	10
N° axial ribs on last whorls + varix	14+v	14+v	13+v	24+v	13-24+v	16.25
N° spiral cords on last whorls above aperture	4	4	5	5(6)*	4-6	4.75
N° spiral cords on last whorls on the base	5	5	6	5	5-6	5.25
Start cord III	2.2	2	1	1.2	1-2.2	1.6
Start cord I	2.7	2.4	2.6	3	2.4-2.7	2.675
Start cord IV			2.5	2.3	2.4-2.7	2.675
Protoconch	1	2	3	4	Min/max	Mean
Height	0.30	0.29	0.30	0.35	0.29-0.35	0.310
Diameter of nucleus	0.12	0.11	0.13	0.14	0.11-0.14	0.125
Diameter of first half whorl	0.24	0.24	0.26	0.25	0.24-0.26	0.247
Maximum diameter	0.36	0.35	0.37	0.37	0.35-0.37	0.362
Number of whorls	1.25	1.25	1.25	1.30	1.25-1.30	1.262

**Tab. 1.** Measurements of the teleoconch and protoconch of *Alvania annetteae* spec. nov. in mm. Number 1: holotype (MNHN); number 2: paratipo (CS-MP); numeri 3 and 4: paratypes (BA).

\* Specimen with micro fracture at c. 2.5 whorls of the teleoconch, resulting in anomalous growth that doubles the IV cord.

**Tab. 1.** Misure della teleoconca e della protoconca di *Alvania annetteae* spec. nov. in mm. Numero 1: olotipo (MNHN); numero 2: paratipo (CS-MP); numeri 3 e 4: paratipi (BA).

\* Esemplare con micro fratture a c. 2,5 giri della teleoconca, con la conseguenza di una crescita anomala che duplica la IV corda.

Systematics

Superorder Caenogastropoda Cox, 1960  
Superfamily Risssoidea Gray, 1847  
Family Risssoidea Gray, 1847  
Genus *Alvania* Risso, 1826

Type-species: *Alvania europea* Risso, 1826: 142, pl. IX, fig. 116 = *Alvania cimex* (Linnaeus, 1758) (*Turbo*), by subsequent designation Nevill, 1885: 105.

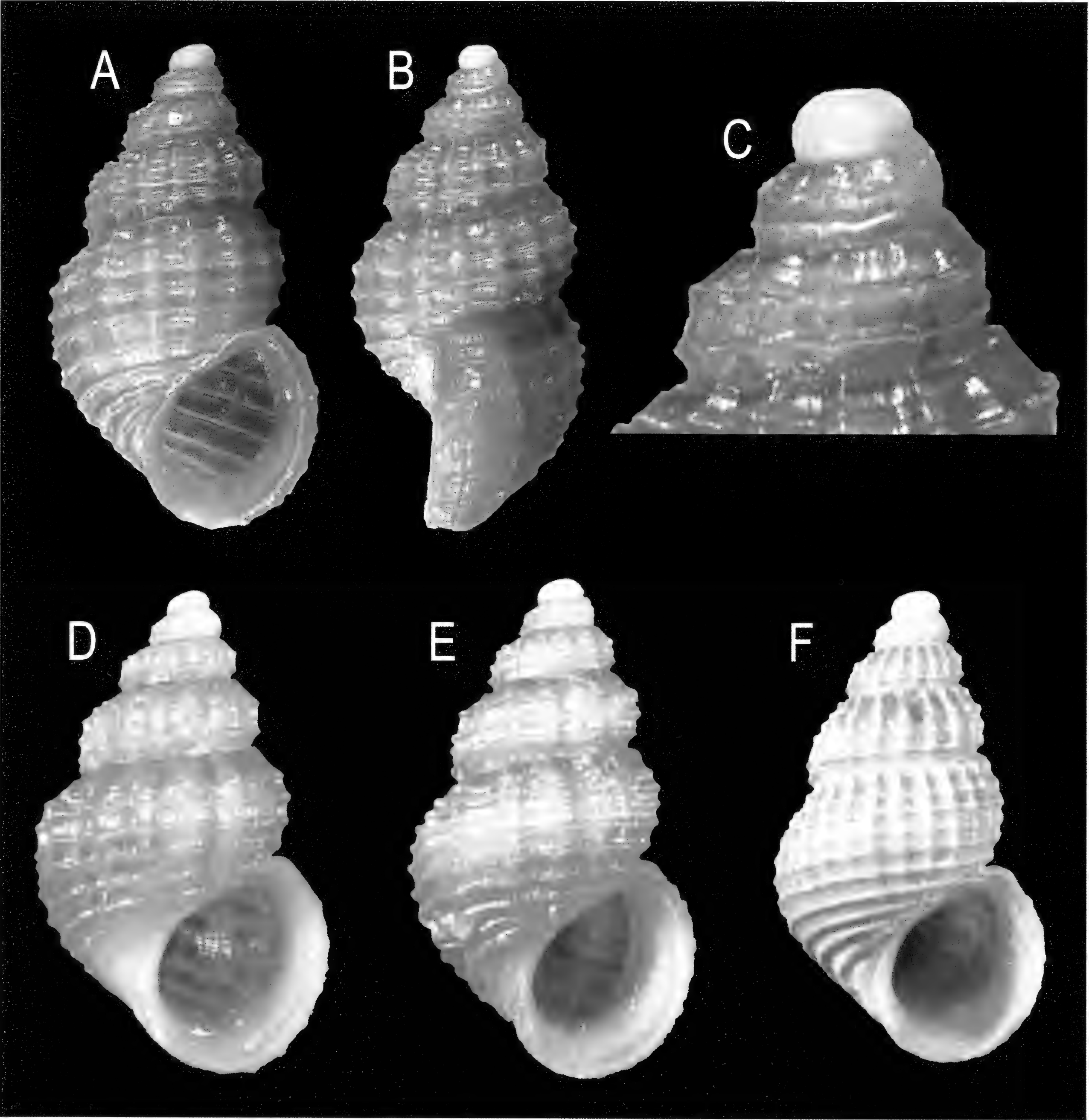
*Alvania annetteae* spec. nov.  
(Figg. 1A-F; 2A-E; 3A, B; Tab. 1)

Type locality

Saint-Raphaël, Côte d’Azur, Southern France, Mediterranean Sea.

Type material

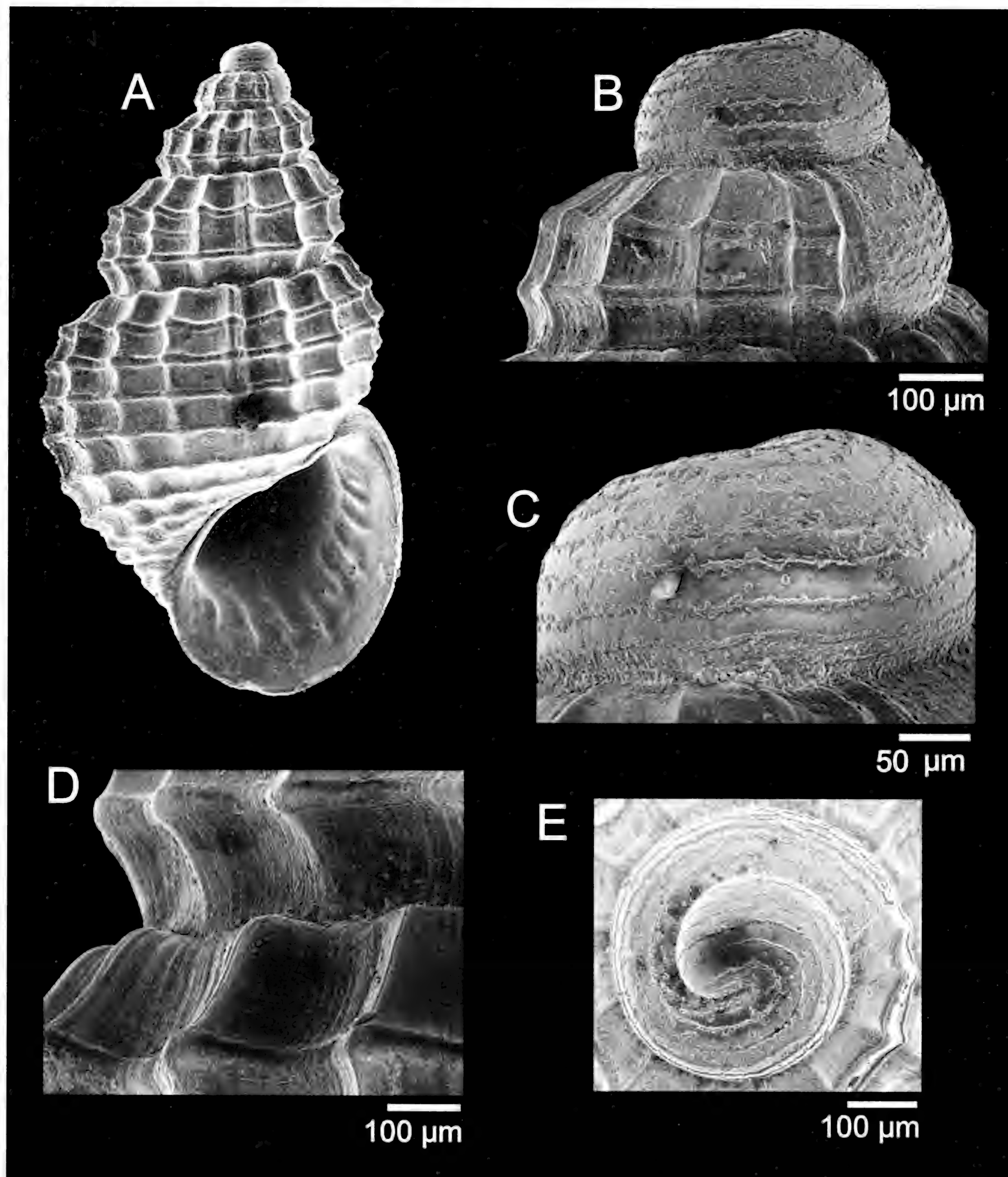
Holotype (MNHN IM-2000-33611) H. 3.05 mm, W. 1.75 mm (legit Claude Danzelle). (Figg. 2A-D). Paratypes: 1 sh (type locality) (GD); 1 sh (type locality) (CD); 2 sh (type locality) (BA); 1 sh (type locality) (CS-PM). Other material examined: 20 adults, 7 juveniles, 5 broken at the aperture, the rest of the shell being very thick and strong (type locality) (CD); 8 adults (type locality) (BA).



**Fig. 1.** *Alvania annetteae* spec. nov. **A-C.** paratype, height 3.2 mm (CD); **D.** paratype, height 3.05 mm (CS-PM); **E and F.** paratypes, height 3.2 mm and 3 mm (BA).

**Fig. 1.** *Alvania annetteae* spec. nov. **A-C.** paratipo, altezza 3,2 mm (CD); **D.** paratipo, altezza 3,05 mm (CS-PM); **E e F.** paratipo, altezza 3,2 mm e 3 mm (BA).





**Fig. 2.** *Alvania annetteae* spec. nov. holotype, height 3.05 mm (MNHN IM-2000-33611). **A.** apertural view, height 3.05 mm; **B, C, E.** particular of protoconch; **D.** detail of the teleoconch micro sculpture.

**Fig. 2.** *Alvania annetteae* spec. nov. olotipo, altezza 3,05 mm (MNHN IM-2000-33611). **A.** vista aperturale, altezza 3,05 mm; **B, C, E.** particolare della protoconca; **D.** dettaglio della teleoconca micro scultura.

## Etymology

after Mrs. Annette Ginisti, wife of one of the authors (Claude Danzelle).

## Description

(in parentheses the data of the holotype) (see **Tab. I** for ranges of measurements). Shell of medium size for the

genus (**Fig. 1A-F; 2A-E; 3A, B**), height 3-3.2 (3.05 mm), width 1.75-1.9 (1.75 mm), glossy, solid, conical-oval-shaped, height/width ratio 1.605-1.743 (1.743). Protoconch paucispiral (**Fig. 1C; 2B, C, E**) with a moderately twisted nucleus, of 1.25-1.30 (1.25) whorls; height 0.29-0.35 (0.30) mm; diameter of the nucleus 0.11-0.14 (0.12) mm; diameter of the first half whorl 0.24-0.26 (0.24) mm; maximum diameter 0.35-0.37 (0.36) mm sculptured by 6-7 fine undulated cordlets; interspaces



with sparse micro tubercles. Protoconch-teleoconch boundary orthocline, well marked (**Fig. 2B**). Teleoconch of 3.9-4 (3.9) convex whorls, with impressed suture. Axial sculpture of thin, orthocline or slightly opisthocline ribs, smaller than the interspaces, 13-24+v (14+v) on the last whorl reaching the base.

Shells with 4 spiral cords on the last whorl above the aperture have 2 cords (II and IV) starting immediately after the protoconch-teleoconch boundary (**Fig. 1E; 2B**), cord III at 1-2.2 whorls, cord I after 2.4-2.7 whorls (**Tab. 1**). Shells with 5 spiral cords on the last whorl above the aperture have 2 cords (II and V) starting immediately after the protoconch-teleoconch boundary, cord III at 1-1.2 whorls, IV cord after 2.3-2.5 whorls, cord I after 2.6-3 whorls; 9-11 (9) thin and equidistant cords on the last whorl, of which 4-5 (4) above the aperture and 5-6 (5) thicker on the base.

Small nodules, formed at the intersection of the two sculptures; deep and square interspaces. Axial ribs in the subsutural area (especially on the last whorl), thickened forming a ripple simulant a tubercle. Micro sculpture on teleoconch (holotype) of fine growth striae and weaker and fewer spiral threads (**Fig. 2D**). Umbilical chink absent. Aperture large, ovate rounded, and pear-shaped, 1.25-1.4 (1.3) mm high, teleoconch height/aperture height ratio 2.259-2.400 (2.346). Outer lip with large varix and sharp edge, orthocline or slightly opisthocline, internally crossed by 9-10 (9) weak and elongated teeth; externally smooth or slightly crossed by spirals cords. Columella smooth. Coloration from yellowish-white to orange-brown with a broad lighter spiral band on middle of the spire; subsutural ramp darker. Protoconch whitish in initial whorls, then turning to same colour as the teleoconch. Operculum and soft parts unknown.

Distribution: So far known only from the type locality, after sorting residuals from trawling at 300-500 m depth who are blocks of volcanic origin of several kilos, presenting numerous cavities filled with mud containing *Alvania annetteae* spec. nov. All samples consisted of empty shells but most of the specimens were in good state of preservation. The most frequent species of *Alvania* found in the same thanatocoenosis were: *Alvania cimicoides* (Forbes, 1844), *Alvania elegantissima* (Monterosato, 1875), *Alvania subsoluta* (Aradas, 1847), *Alvania testae* (Aradas & Maggiore, 1844) and *Alvania dipacoi* Giusti & Nofroni, 1989 (see also **Tab. 2**), with a total of 14 gastropods and 7 bivalve species. All were deep-water species, characteristic of continental shelf bathyal bottoms.

## Remarks

A wide range of variability (see **Fig. 1A-F**, also **Tab. 1**) of the profile of the shell is evident in the H/W ratio 1605-1743; in the number of axial ribs on the last whorl (13-30) and in the spirals cords on the last whorl (9-11). One shell was devoid of teeth inside the outer lip.

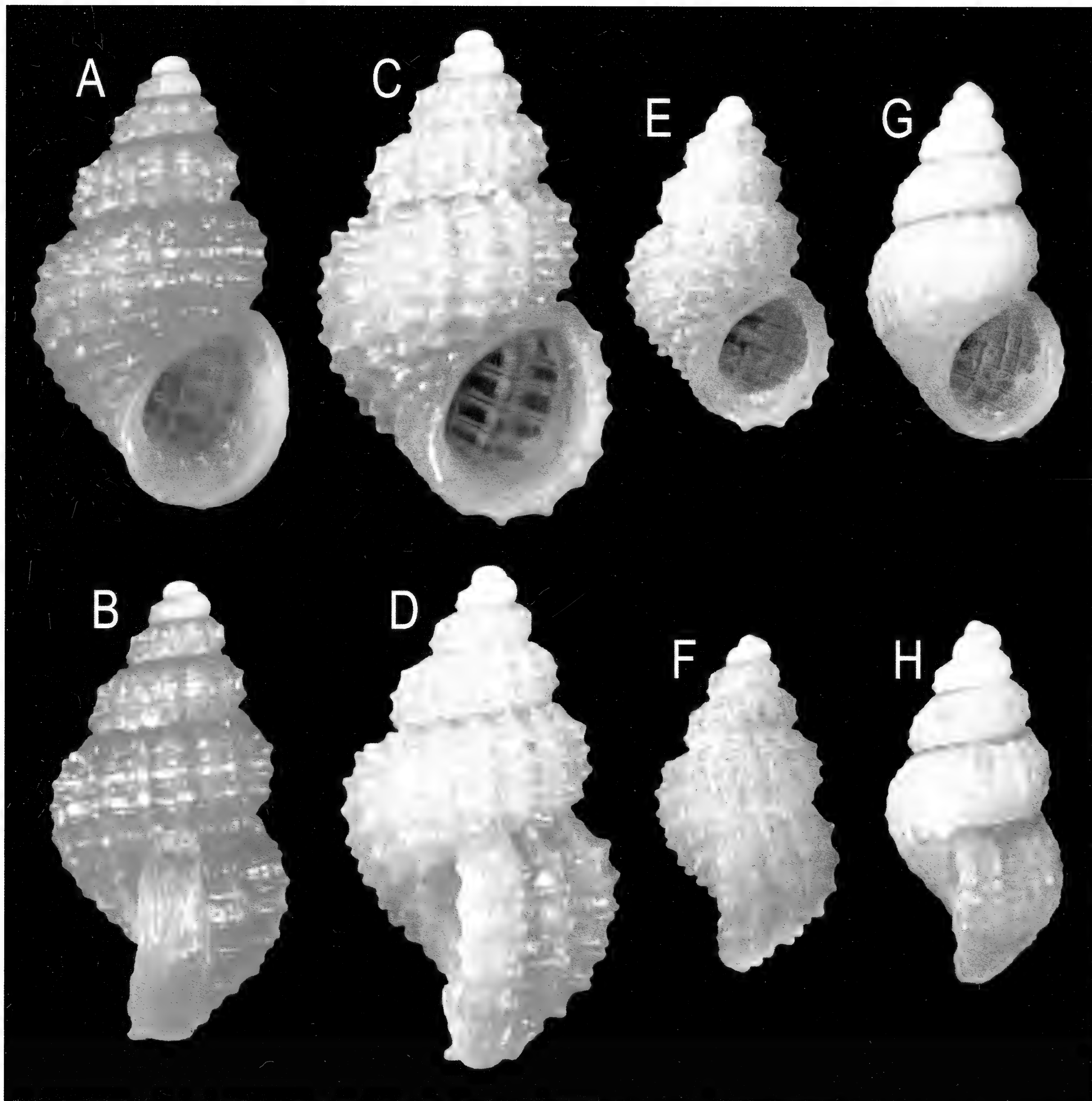
*Alvania hallgassi* Amati & Oliverio, 1985 (**Fig. G, H**; see also Amati & Oliverio, 1985: 34, figg. 1-2; Giannuz-

zi-Savelli et al., 2002: 107, figg. 437-440; Scaperrotta et al. 2012: 49, 5 unnumbered figg.; Romani, 2014: 513-514 figg. 9-11, 14; Romani et al. 2017: 37, figg. 6A-B) differs from *Alvania annetteae* spec. nov. by its thinner shell and smaller size (H. 2-2.3 mm *v.* H. 3-3.2 mm in *A. annetteae* spec. nov.); the fewer teleoconch whorls (3-3.5 *v.* 3.9-4 in *A. annetteae* spec. nov.); the protoconch with 5-6 spiral threads and the nucleus with only the first and last threads with interspaces smooth *v.* 6-7 fine undulated cordlets and the interspaces with evident micro tubercles in *A. annetteae* spec. nov. Recently Romani (2014) and Romani et al. (2017) have suggested, based on the similarities of the shell morphology, that *A. dalmatica* may fall within the range of variability of *A. hallgassi*. However, *Alvania dalmatica* Buzzurro & Prkić, 2007 (**Fig. C, D**; see also Buzzurro & Prkić, 2007: 6, figg. 1a-d; Romani, 2014: 513-514, figg. 1-8; Micali & Siragusa, 2013: 28, fig. 1B (as *A. daniensis*); Romani et al. 2017: 37, figg. 6C-D) differs from *Alvania annetteae* spec. nov. in its protoconch with 6-7 fine cordlets and interspaces with the presence of rare micro tubercles *v.* 6-7 undulated cordlets and interspaces with evident micro tubercles in *A. annetteae* spec. nov.; in the larger maximum protoconch diameter and 0.38-0.41 mm (Romani, 2014: 511, tav. 2) *v.* 0.35-0.37 mm in *A. annetteae* spec. nov.; the different sequence of start of the spiral cordlets: I-IV immediately after the protoconch-teleoconch boundary, cord III at 1.4 whorls, cord II after 2.2 whorls in *A. dalmatica* *v.* II and IV or II and V starting immediately after the protoconch-teleoconch boundary in *A. annetteae* spec. nov., followed subsequently by I and III (with 4 cords above the aperture) or I, III and IV (with 5 cords above the aperture); the outer lip with large varix without sharp edge, orthocline, externally crossed by robust spiral cords in *A. dalmatica* *v.* large varix and sharp edge, orthocline or slightly opisthocline, externally smooth or crossed by very weak spirals cords in *A. annetteae* spec. nov. Additionally, *Alvania dalmatica* is collected always on shallower coralligenous bottoms (40 m depth) (Romani, 2014: 512) with presence of *Corallium rubrum* (Linnaeus, 1758) (60-90 m depth) (Buzzurro & Prkić, 2007: 5, 7) *v.* 300-500 m depth, on muddy rocky bottoms for *A. annetteae* spec. nov.

*Alvania daniensis* Oliverio, 1988 (**Fig. E, F**; see also Oliverio, 1988: 120, fig. 6,7; Buzzurro et al., 1999: 40, fig. 5; Giannuzzi-Savelli et al., 2002: 105 figg. 117-120; Micali & Siragusa, 2013: 28 fig. 1A; Scaperrotta et al., 2013: 49, 5 unnumbered figg.) differs from *Alvania annetteae* spec. nov. by lacking the teeth inside the outer lip, its smaller size (H. 2-2.4 mm. *v.* H. 3-3.2 mm in *A. annetteae* spec. nov.); 3 spiral cords on the last whorl, above the aperture *v.* 4-5(6) in *A. annetteae* spec. nov.; the whitish-yellowish, uniform colour *v.* yellowish-white to orange-brown background with a broad lighter spiral band on the middle of the spire and a darker subsutural ramp in *A. annetteae* spec. nov. Additionally, *Alvania daniensis* lives in shallower habitat (15-48 m depth) and has never been collected (even empty shells) at the depth (300-500 m depth) of *A. annetteae* spec. nov.

*Alvania testae* (Aradas & Maggiore, 1844) (see Bouchet &





**Fig. 3.** *Alvania* spp. **A, B.** *Alvania annetteae* spec. nov. holotype, height 3.05 mm (MNHN IM-2000-33611); **C, D.** *Alvania dalmatica* Buzzurro & Prkic, 2007, topotype, Lastovo Is. (Croatia) -60/90 m, height 3.35 mm (CS-PM); **E, F.** *Alvania daniensis* Oliverio, 1988, paratype, Giannutri Is., Cala dei Grottoni -48 m (GG48) (Italy), height 2.25 mm (BA); **G, H.** *Alvania hallgassi* Amati & Oliverio, 1985, paratype, Gallipoli (Italy) beached, height 2.45 mm (BA).

**Fig. 3.** *Alvania* spp. **A, B.** *Alvania annetteae* spec. nov. olotipo, altezza 3,05 mm (MNHN IM-2000-33611); **C, D.** *Alvania dalmatica* Buzzurro & Prkić, 2007, topotipo, Isola di Lastovo (Croatia) -60/90 m, altezza 3,35 mm (CS-PM); **E, F.** *Alvania daniensis* Oliverio, 1988, paratipo, Giannutri Is., Cala dei Grottoni - 48 m (GG48) (Italia), altezza 2,25 mm (BA); **G, H.** *Alvania hallgassi* Amati & Oliverio, 1985, paratipo, Gallipoli (Italia) spiaggiata, altezza 2,45 mm (BA).

Warén, 1993: 627, 630, figg. 1386-1387, 1400-1405; Oliverio et al., 1993: 255, figg. 1-3; Giannuzzi-Savelli et al., 2002: 105, figg. 413-416; Chirli & Linse, 2011: 83, tav. 24, figg. 1a-e; Scaperrotta et al., 2012: 58, 5 unnumbered figs; Garilli & Parrinello, 2014: 387, figg. 8A-B; Bitlis Bakir & Öztürk, 2016: 448, fig. 2 21; Bitlis Bakir & Öztürk, 2017: 10, figg. 5K-L) differs from *Alvania annetteae* spec. nov. mainly in its multispiral protoconch (indicating a planktotrophic development) *v.* paucispiral protoconch and lecithotrophic development in *A. annetteae* spec. nov. and in its strongly opisthocline outer lip *v.* orthocline or slightly opisthocline in *A. annetteae* spec. nov.

*Alvania subsoluta* (Aradas, 1847) (see Bouchet & Warén, 1993: 645-647, 649, figg. 1453-1461, 1464-1474; Oliverio et al., 1993: 256, figg. 4-10; Gaglini, 1991: 16, 1 unnumbered fig.; Ardovini & Cossignani, 1999: 38, 1 unnumbered fig.; Giannuzzi-Savelli et al., 2002: 107, figg. 425-428; Scaperrotta et al., 2012: 57, 5 unnumbered figg;) differs from *Alvania annetteae* spec. nov. in its smaller size ( $H < 3$  mm *v.*  $\geq 3$  mm in *A. annetteae* spec. nov.), the finer sculpture, the more globose apex with different sculpture and the lip more markedly opisthocline. *Alvania desabatae* Amati & Smriglio, 2016 (see Amati & Smriglio, 2016: 167, 169, figg. 1I-K; 2G-I, L) differs from

	GASTROPODA	FAMILY	ABUNDANCE
1	<i>Propilidium exiguum</i> (W. Thompson, 1844)	LEPETIDAE	++
2	<i>Putzeysia wiseri</i> (Calcara, 1842)	CALLIOTROPIDAE	++
3	<i>Copulabyssia corrugata</i> (Jeffreys, 1883)	PSEUDOCOCCULINIDAE	++
4	<i>Moelleriopsis messanensis</i> (Seguenza, 1876)	SEGUENZIOIDEA	++
5	<i>Akritogyra conspicua</i> (Monterosato, 1880)	SEGUENZIOIDEA	++
6	<i>Alvania cimicoides</i> (Forbes, 1844)	RISSOIDAE	++
7	<i>Alvania dipacoi</i> Giusti Fr. & Nofroni, 1989	RISSOIDAE	+
8	<i>Alvania elegantissima</i> (Monterosato, 1875)	RISSOIDAE	++
9	<i>Alvania subsoluta</i> (Aradas, 1847)	RISSOIDAE	++
10	<i>Alvania testae</i> (Aradas & Maggiore, 1844)	RISSOIDAE	+++
11	<i>Raphitoma pseudohystrix</i> (Sykes, 1906)	RAPHITOMIDAE	+
12	<i>Sorgenfreispira brachystoma</i> (Philippi, 1844)	MANGELIIDAE	+
13	<i>Xylodiscula lens</i> Warén, 1992	XYLODISCULIDAE	+
14	<i>Parthenina flexuosa</i> (Monterosato, 1874)	PYRAMIDELLIDAE	+
	BIVALVIA		
15	<i>Yoldiella philippiana</i> (Nyst, 1845)	YOLDIIDAE	+
16	<i>Microgloma tumidula</i> (Monterosato, 1880)	YOLDIIDAE	++
17	<i>Microgloma pusilla</i> (Jeffreys, 1879)	YOLDIIDAE	+
18	<i>Limea crassa</i> (Forbes, 1844)	LIMIDAE	++
19	<i>Kelliella miliaris</i> (Philippi, 1844)	KELLIELLIDAE	+
20	<i>Abra longicallus</i> (Scacchi, 1835)	SEMELIDAE	++
21	<i>Tropidomya abbreviata</i> (Forbes, 1843)	CUSPIDARIIDAE	+

**Tab. 2.** Systematic list of the species found in the same thanatocoenosis as *Alvania annetteae* spec. nov. and the indication of abundance: + = rare; ++ = common; +++ = very common. Systematics based on the World Register of Marine Species.

**Tab. 2.** Elenco sistematico delle specie trovate nella stessa tanatocenosi come *Alvania annetteae* spec. nov. e l'indicazione di abbondanza: + = rara; ++ = comune; +++ = molto comune. Sistematica basata sul Registro Mondiale delle Specie Marine (WO. R. M. S.).

*Alvania annetteae* spec. nov. in its smaller size (H 1.80-2.35 mm *v.* H. 3-3.2 mm in *A. annetteae* spec. nov.); the sculpture of the protoconch nucleus and the first half whorl with some fine undulated spiral cordlets, more evident on the suprasutural area, separated by randomly arranged micro tubercles and sparse, large, roughly triangular tubercles, randomly arranged on the remaining whorls *v.* 6-7 series of undulated cordlets and interspaces with evident buds in *A. annetteae* spec. nov. *Alvania marmarisensis* Bitlis Bakir & Öztürk, 2017 (see Bitlis Bakir & Öztürk, 2017: 11, 13, figg. 6A-F, figg. 7A-E) has a very similar shell to *Alvania annetteae* spec. nov.; it differs essentially in the more acute outline, with less convex whorls; it has a half whorl more at the same shell length; the slightly larger tubercles at the intersections; the fewer internal denticles on the outer lip (7 *v.* 9-11 in *A. annetteae* spec. nov.); the inclination of the lip is slightly prosocline *v.* orthocline or slightly opisthocline in *A. annetteae* spec. nov.; the light brown colour with dark apex *v.* yellowish-white to orange-brown with a broad lighter spiral band on the middle of the spire, darker subsutural ramp, and whitish first whorls of the protoconch in *A. annetteae* spec. nov. Additionally, *Alvania marmarisensis* has been collected at 99 m depth on muddy bottoms in Turkey, Aegean Sea, *v.* 300-500 m depth on muddy bottoms in Southern France, Mediterranean Sea.

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Subfamily Cardiinae Lamarck, 1809  
Genus *Acanthocardia* Gray, 1853  
type species *Cardium aculeatum* Linné, 1758)

*Cardium indicum* Lamarck, 1819  
**Fig. 1A-D, Fig. 2C)**

*Cardium hians* Brocchi, 1814: p. 508, tav. 13, fig. 6 (non Spengler, 1799).  
*Cardium indicum* Lamarck, 1819: p. 4.  
*Cardium (Cardium) indicum* Lamarck – Fischer-Piette, 1977: p. 112, tav. 10, fig. 4 (tipo).

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